Technology Review

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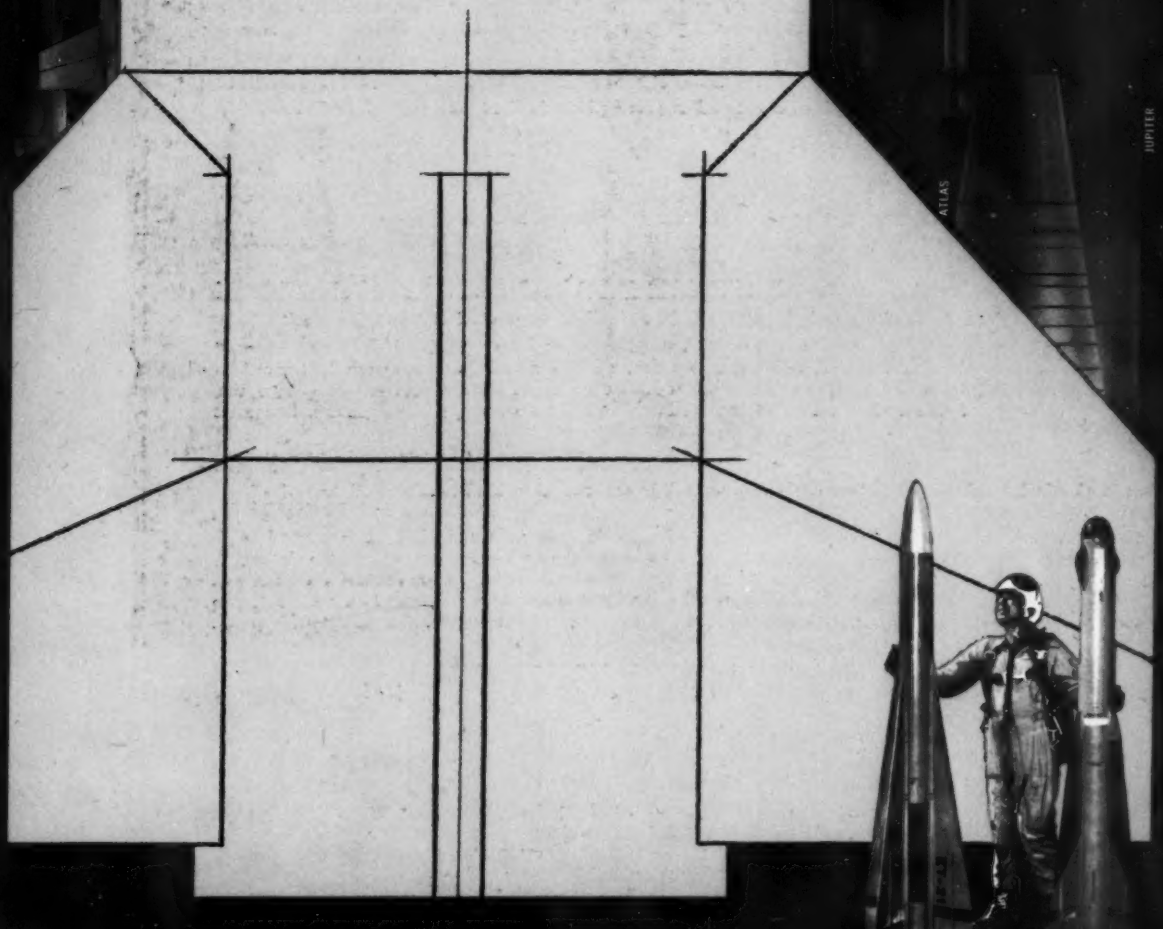

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This second edition has been revised extensively, and the principal additions include: (1) an article on deflection of plates due to transverse shear, (2) an article on stress concentrations around a circular hole in a bent plate, (3) a chapter on bending of plates resting on an elastic foundation, (4) a chapter on bending of anisotropic plates, and (5) a chapter reviewing certain special and approximate methods used in plate analysis.

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Technology Review

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Volume 62 Number 5 *Edited at the Massachusetts Institute of Technology* *March, 1960*

Feedback

Pupil's Re-creation
Or Teacher's Recreation

FROM PHILIP FRANKLIN:

In the last few years, there has developed widespread awareness of the importance of an early study of mathematics in the training of engineers and physical scientists. This has caused several groups to re-evaluate the high school curriculum in mathematics, and to implement many of their ideas through institutes for teachers such as those of the National Science Foundation. An effort of this kind at the Junior High School or even the primary grades level, the Madison Project, was described by Professor Robert B. Davis in a recent article in The Technology Review (Dec., 1959, pp. 28-30).

The objective of these efforts is laudable — to improve and modernize the teaching of the traditional high school mathematics subjects. But some of the apparently demonstrated conclusions about learning mathematics can easily be carried too far, and it is this caution that the writer would like to emphasize.

That the small number of "low-I.Q." students per teacher helped maintain interest was to be expected. And that, when the teachers felt the zeal of a new "educational experiment," they imparted interest to the students is quite believable. However, this last effect is hard to sustain over a period of years.

But that changes in language and notation had much virtue seems doubtful. An example was the use of the relatively vague words "general mathematics" and "condition" for the much more precise terms "algebra" and "equation." And compare the Project's formulation:

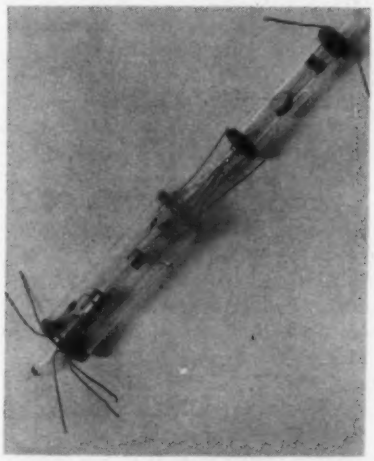
If $3 + \square = 5$, what goes in the box?

with the traditional formulation:

Solve $3 + x = 5$.

The "new" notation is costlier to print, but is it new? It is strongly reminiscent of the formulations of Diophantos of Alexandria (c. 350 A.D.). The full appreciation by mathematicians of the notation $ax + b = c$, with any of the letters positive or negative, dates from the "Geometry" of Descartes in 1637. Present-day engineering students are still a little incredulous the first time they encounter

(Continued on page 49)



THIS VACUUM TUBE was made from a kit of parts that is now being evaluated in the schools. How it was assembled is described in the article on page 40.

The Cover

Pegasus posed in the center of the Kresge Auditorium, facing the organ, for The Review's cover. The sculpture is described in the article on pages 21 and 22.

EDITOR: Volta Torrey; BUSINESS MANAGER: R. T. Jope,'28; CIRCULATION MANAGER: D. P. Severance,'38; EDITORIAL ASSOCIATES: J. J. Rowlands, Francis E. Wylie, John I. Mattill; EDITORIAL STAFF: Ruth King, Diana de Filippi; BUSINESS STAFF: Madeline R. McCormick, Louise E. Ryan; PUBLISHER: H. E. Lobdell,'17.

The Technology Review is published monthly from November to July inclusive, on the 27th day of the month preceding the date of issue, by the Alumni Association of M.I.T.; Edward J. Hanley, '24, President; H. E. Lobdell,'17, Executive Vice-president; William W. Garth, Jr.,'36, William L. Taggart, Jr.,'27, Vice-presidents; Donald P. Severance,'38, Secretary-Treasurer.

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Editorial and business offices are in Room 1-281, Massachusetts Institute of Technology, Cambridge 39, Mass. The Review is published at Hildreth Press, Inc., Emmett Street, Bristol, Conn.

An annual subscription in the U.S. is $4.00; in Canada and elsewhere, $4.50; a single copy, 60 cents. Three weeks must be allowed to effect a change of address, for which both the old and the new address should be given.

Entered as second-class matter December 23, 1949, at the Post Office, at Bristol, Conn., under the Act of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 338, P. L. & R. Act of February 28, 1925.

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Individuals Noteworthy

New Advisory Council

ANOTHER LINK between the business world and M.I.T. was formed this winter when Dean Howard W. Johnson of the School of Industrial Management announced the formation of a new Advisory Council under the chairmanship of Alfred P. Sloan, Jr., '95, Honorary Chairman of the General Motors Corporation and President of the Alfred P. Sloan Foundation which established the school.

"Our council members will serve the school," said Dean Johnson, "by providing advice and counsel on its various study and research programs, and by acting as a sounding board for new ideas."

Council members, who will serve for three years, are:

Albert Bradley, Director and Former Chairman of the Board, General Motors Corporation, and Chairman, Alfred P. Sloan Foundation, Inc.

Russell DeYoung, '40, President, Goodyear Tire and Rubber Co.

Bradley Dewey, '09, Former President, Dewey & Almy Chemical Division, (W. R. Grace & Co.)

Cecil H. Green, '23, Honorary Chairman of the Board, Geophysical Service Inc.

Robert T. Haslam, '11, Consultant and Director, W. R. Grace & Co.

Wayne J. Holman, Jr., '39, Chairman of the Board, Chicopee Manufacturing Corporation.

Theodore V. Houser, Former Chairman of the Board, Sears, Roebuck & Company.

George M. Humphrey, Chairman of the Board, National Steel Corporation.

Devereux C. Josephs, Chairman of the Board, New York Life Insurance Company.

Frederick R. Kappel, President, American Telephone & Telegraph Company.

Semon E. Knudsen, '36, General Manager, Pontiac Motor Division, General Motors Corporation.

George J. Leness, '26, Chairman of the Executive Committee, Merrill, Lynch, Pierce, Fenner and Smith, Inc.

William B. Murphy, President, Campbell Soup Company.

Alfred C. Neal, President, Committee for Economic Development.

Robert C. Sprague, '23, Chairman and Treasurer, Sprague Electric Company.

John C. Virden, Chairman of the Board and President, Eaton Manufacturing Company.

Thomas J. Watson, Jr., President, IBM Corporation.

James E. Webb, Director, Kerr-McGee Oil Industries, Inc.

Arnold J. Zurcher, Vice-president and Executive Director, Alfred P. Sloan Foundation, Inc.

To Resume Teaching

ONE of the foremost authorities in the communications-systems field, Wilbur B. Davenport, Jr., '43, will resume teaching next fall as professor of electrical engineering at M.I.T. after nine years on the staff of Lincoln Laboratory.

Wilbur B. Davenport, Jr., '43

PAUL A. SAMUELSON, Professor of Economics at M.I.T., was elected First Vice-president of the American Economic Association at its recent meeting in Washington. His textbook on economics is used in many schools.

Dr. Davenport was a teaching assistant in the Department of Electrical Engineering from 1941 to 1943. He then served for three years as a fire-control radar officer in the United States Navy. After more years on the M.I.T. Faculty, he went to Lincoln, where he has served in the Communications and Components Division and, since 1958, as head of the Information Processing Division.

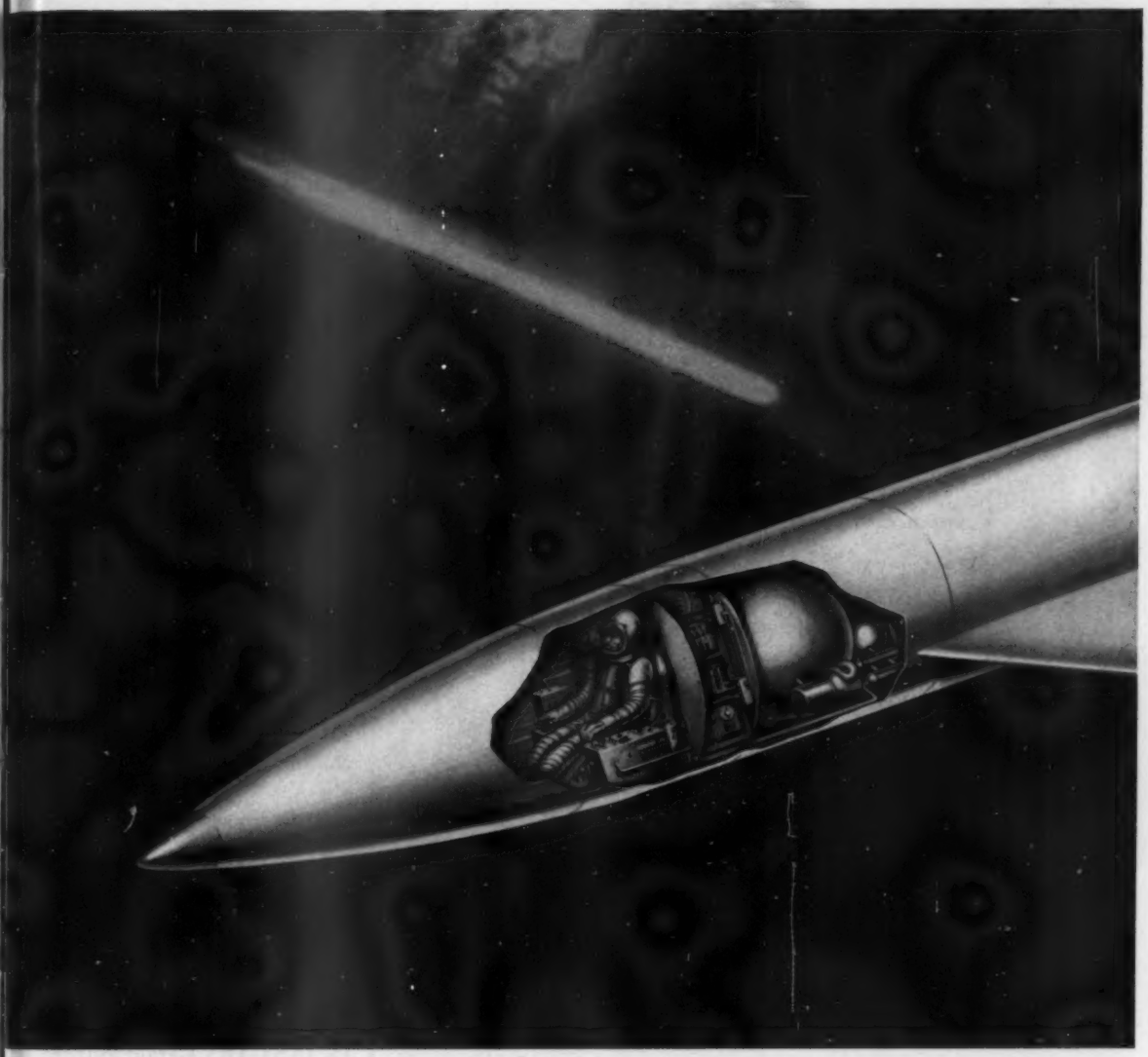
He is a consultant to the Director of Defense Research and Engineering, the National Security Agency and the U.S. Navy Special Projects Office. He was co-author with William L. Root, '43, of *An Introduction to the Theory of Random Signals and Noise* in 1958, and is a fellow of the Institute of Radio Engineers.

"Dr. Davenport is an unusual combination of skillful teacher, keen research man, and bold leader of advanced engineering work," says Jerome B. Wiesner, Acting Head of the Electrical Engineering Department. "He will be able to contribute very substantially to the work on engineering education and on communication sciences that we have planned for the next decade."

(Continued on page 6)

NO. 31 IN A SERIES

OUT OF THE LABORATORY



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Individuals Noteworthy

(Continued from page 4)

Warren J. Mead: 1883–1960

PROFESSOR EMERITUS of Geology Warren Judson Mead died on January 16 at his home in Belmont. Dr. Mead headed the M.I.T. Department of Geology from 1934 until he retired in 1949.

Born in Plymouth, Wis., in 1883, Dr. Mead was graduated from the University of Wisconsin in 1906, where he received his master's in 1908 and his doctorate in 1926. He was a member of the Wisconsin faculty from 1906 until 1934. He wrote numerous geological papers and collaborated with C. K. Leith in producing the volume entitled *Metamorphic Geology* (1915). His nonacademic work included consulting for the Panama Canal Commission, the Corps of Engineers, the Colorado River Board to determine the feasibility of Boulder Dam, the Aluminum Company of America, and the Reynolds Metal Company. He also investigated iron and coal resources of South Manchuria.

Dr. Mead was a member of the National Academy of Sciences and a fellow of the American Academy of Arts and Sciences and the Geological Society of America.

He is survived by his wife, Bertha Taylor Mead, and three sons, Warren, of Waterloo, Iowa; Judson, of Bloomington, Ind.; and Jeremiah, of Waban, Mass.

Gerald Putnam: 1902–1960

IN JANUARY Gerald Putnam, '23, Assistant Professor of Engineering Graphics in the Department of Mechanical Engineering, died in a Cambridge hospital.

Professor Putnam was born on November 27, 1902, in Clinton, Mass. He worked with water power engineering companies in Albany before joining the Institute Faculty in 1933, and held positions in the Departments of Civil Engineering, Drawing and Graphics before joining the Mechanical Engineering Department. He also served as lecturer in mathematics at Tufts University and Northeastern University.

He is survived by his wife, Dorothy Valentine Putnam.

(Continued on page 12)

. . . a hand in things to come

Shaping another sun

7000 degrees . . . an inferno approaching that of the sun's surface has been created by the scientists of Union Carbide. The energy comes from the intensely hot carbon arc. Through the use of mirrors, the heat is reflected to form a single burning image of the electric arc at a convenient point. Called the arc-image furnace, it extends the limits of high-temperature research on new materials for the space age.

For years, mammoth carbon and graphite electrodes have fired blazing electric furnaces to capture many of today's metals from their ores and to produce the finest steels. But, in addition to extreme heat, the carbon arc produces a dazzling light that rivals the sun. In motion picture projectors, its brilliant beam floods panoramic movie screens with every vivid detail from a film no larger than a postage stamp.

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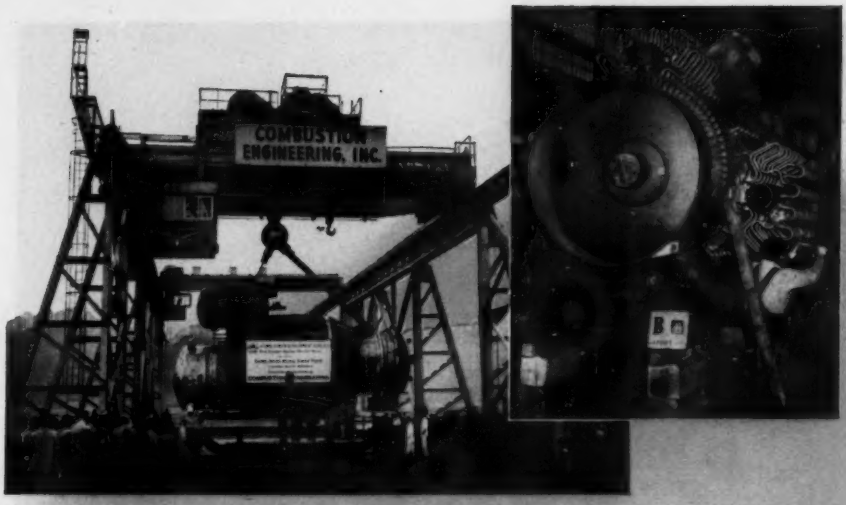
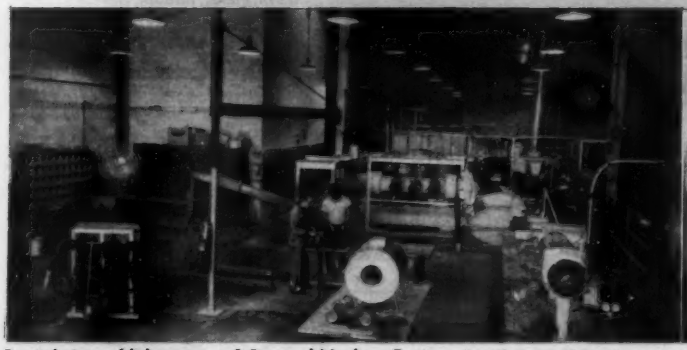


(Left) The huge riverside crane at Combustion's Chattanooga Division easily lifts this 92-ton stainless steel reactor vessel — the most complex reactor vessel built to date — into a barge for shipment to the Enrico Fermi Power Station, Lagoona Beach, Michigan.
(Right) Stainless steel sodium heat exchanger consisting of a series of tubes within tubes, encased in a pressure vessel.

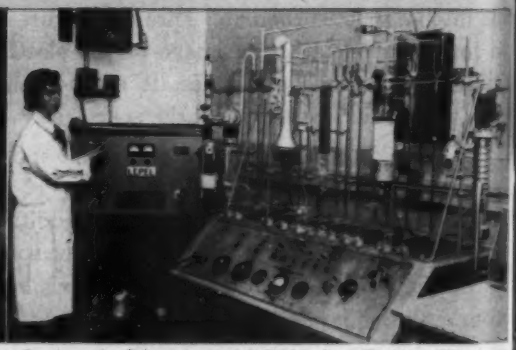
What C-E is doing to advance N

The strange and wondrous world of the atom has been examined and surveyed by C-E scientists and engineers since 1946. The object—to put the controlled energy of the atom to productive use for the generation of power. The result—a wealth of knowledge and experience in the application, design and manufacture of nuclear power equipment. Backed by specially designed laboratories and manufacturing facilities, this knowledge and experience—greatly augmented and enriched by the acquisition of the General Nuclear Engineering Corporation early last year—has enabled C-E to undertake many kinds of nuclear work.

Notable C-E and General Nuclear projects are outlined on the opposite page. Virtually all of them are *current*, and many have a significant relationship to the vital task of making nuclear power competitive with conventional power. Collectively, these projects will contribute importantly to the Company's objective of achieving the same position of leadership in the atomic world of tomorrow which it has long since achieved in present-day methods of power generation.



Partial view of laboratory of General Nuclear Engineering Corporation at Dunedin, Florida, showing equipment used for the study of a high-pressure, high-temperature gas coolant system.



Portion of a laboratory at C-E's Nuclear Division, Windsor, Connecticut, showing gas analysis equipment used for detecting the presence of small quantities of gases in reactor materials.

The 520-foot-long Heavy Vessel Bay at C-E's Chattanooga Division was created especially for the manufacture of heavy nuclear components.

Portion of the 530-acre site occupied by C-E's Nuclear Division at Windsor, Connecticut. This Division is equipped for the development, design and test of reactor systems and the manufacture of reactor cores and core components.

Nuclear Power Progress

C-E NUCLEAR PROJECTS

For Electric Power Stations

- In association with Stone & Webster Engineering Corporation, a design study for AEC of an advanced type of large (236,000 kw) pressurized water reactor power plant.
- A long-term development program for AEC to determine the best means of using nuclear energy to generate superheated steam. (Success in this endeavor will be a big step forward in reducing the cost of nuclear-generated power.)
- Design studies for the Puerto Rico Water Resources Authority, under AEC contract, to determine the best means of adding nuclear superheat to a boiling water reactor.
- Design, research and development work covering a gas-cooled, heavy-water-moderated, pressure-tube type reactor for the East Central Nuclear Group, Inc., and the Florida West Coast Nuclear Group. This development will also lead to a nuclear power plant using superheated steam.
- The development and test of various kinds of fuel elements and fabricating procedures, under contract with the AEC.
- The design and manufacture of reactor vessels, including the largest and most complex vessels of their type built to date, for the Shippingport Station (America's first full-scale atomic power plant), the Enrico Fermi Atomic Power Plant, the Humboldt Bay Nuclear Power Station, and Italy's first nuclear power plant.

For Military Power Plants

- Design study for U. S. Army, under AEC contract, of a truly package type of nuclear reactor, using the boiling water concept, for remote installations. This program includes operation of a prototype boiling water reactor at the National Reactor Testing Station in Arco, Idaho, and the training of military technicians in the operation of the installation.
- The conceptual design and operation of a nuclear test reactor, under AEC contract, to permit full-scale testing of prototype reactor cores for military field plants.

For Naval Power Plants

- The design and manufacture of a submarine reactor system designed to set new standards of accessibility, speed of startup and operational flexibility—and the operation of a land-based prototype installation.
- The design and manufacture of numerous reactor cores, reactor vessels, steam generators and pressurizers for various types of submarines and naval surface ships.

For Merchant Ship Propulsion

- The design and engineering study of a prototype pressurized water reactor for a 45,000-ton tanker, under contract with the AEC and the U. S. Maritime Commission.

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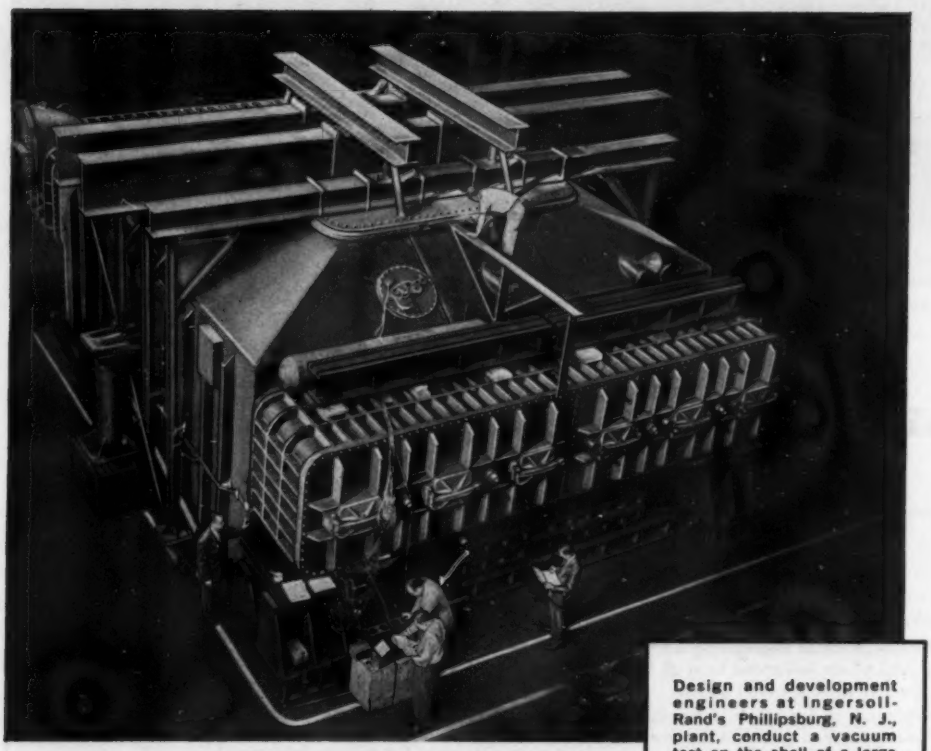

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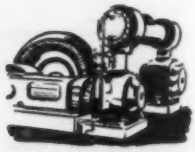

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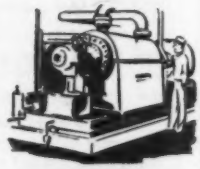
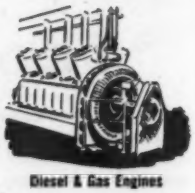


Centrifugal Pumps

Rock Drills

Air & Electric Tools



Diesel & Gas Engines

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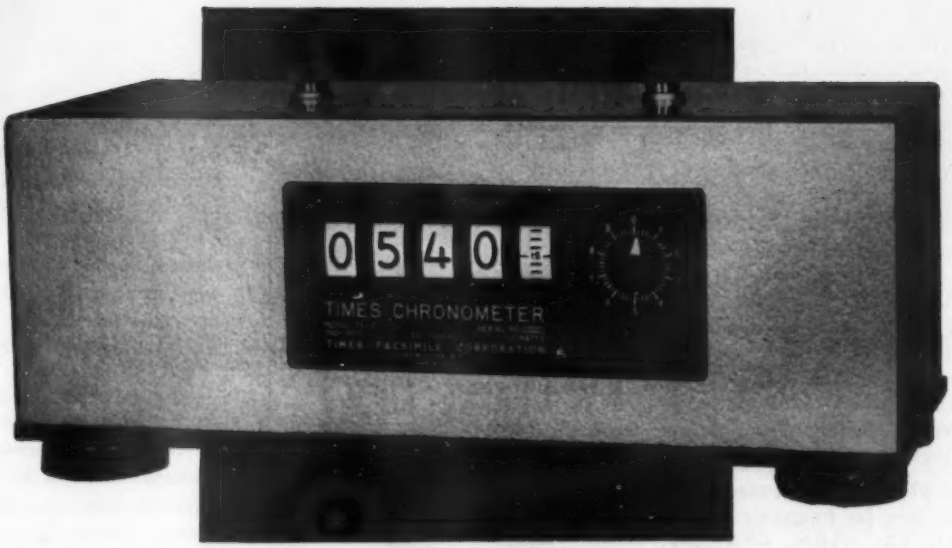

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Arthur E. Raymond, Senior Engineering Vice President of Douglas, goes over a proposed lunar trajectory with Maxwell Hunter, Asst. Chief Engineer—Space Systems

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The new NASA Thor-boosted research rocket, DELTA, now in production at Douglas, will set up important signposts for further space explorations.

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MISSILE AND SPACE SYSTEMS ■ MILITARY AIRCRAFT
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Individuals Noteworthy

(Continued from page 6)

Burdell to Ankara

RETIRING after 22 years' service as the chief administrative officer of The Cooper Union, Edwin S. Burdell, '20, this month assumes the presidency of the Middle East Technical University in Turkey.

Dr. Burdell became a member of the M.I.T. Faculty upon his appointment as Associate Professor of Sociology in 1934. He was named as the first Dean of Humanities in May, 1937, at which time President Karl T. Compton said the creation of the deanship was "another significant step in the efforts of this institution to meet the challenge of a changing social order in America." In 1938, Dr. Burdell resigned as Dean to become Director of The Cooper Union, which title became that of President in 1951.

The Middle East Technical University at Ankara was organized by the United Nations Educational, Scientific, and Cultural Organization in 1958. It now has 600 students, and an eventual enrollment of 20,000 is planned. The university has faculties in architecture, engineering, administration, agriculture, and education.

(Continued on page 46)

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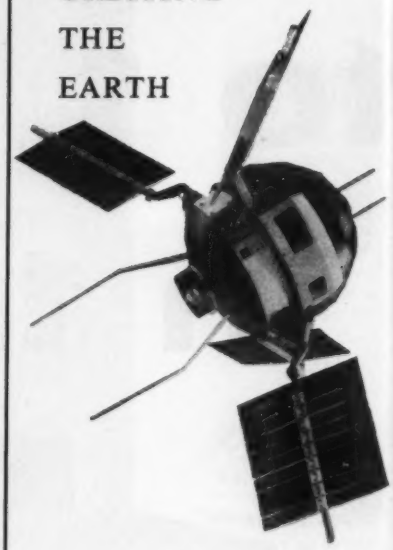

Space Technology Laboratories carried out the Able III program which put Explorer VI in space...one of a series of advanced scientific experiments conducted by STL in conjunction with the Air Force on behalf of NASA.

STL's leadership in military applications of space technology is illustrated by its successful accomplishments as the contractor responsible for over-all systems engineering and technical direction of the Atlas, Titan, Thor, and Minuteman programs. Scientists and engineers with outstanding capabilities relating to these activities, are invited to investigate positions at STL.

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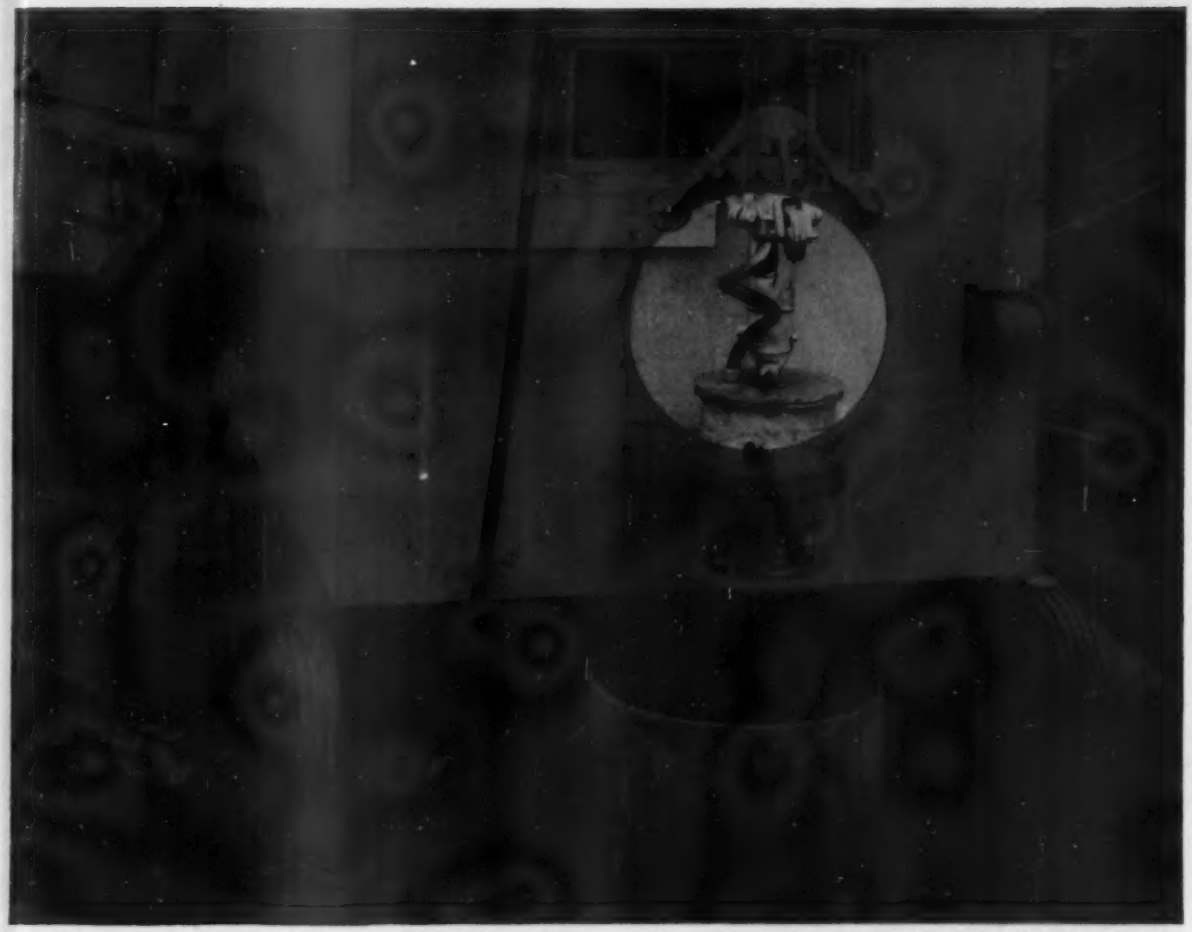

OPTIC NERVE FOR EYES THAT SEE 100 FEET BELOW THE SURFACE

This is a television camera. Its job is to photograph the substrata of excavations, thereby providing information needed by engineers in planning the construction of Boston's new Prudential Center, a modern, multi-million dollar real estate development.

Here in the Back Bay section of Boston, with its artificially maintained water table, this sealed camera must go down into a water-filled hole 100 feet below the surface. To transmit the picture from the camera to the surface monitor, Lake Service Corp. of Brighton, Massachusetts, designers and manufacturers of the television equipment, chose Simplex Anhydrex XX insulated cable because of its ability to withstand the rigors of submarine and direct burial duty.

For all types of service involving high and low voltages, whether aerial, underground or submarine, or for everyday plant wiring, it pays to call a Simplex Engineer.

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These programs include: celestial mechanics; computer research and development; electromagnetic wave propagation and radiation; electronics; the flight sciences; human engineering; magnetohydrodynamics; man in space; materials and processes; applied mathematics; operations research and analysis; ionic, nuclear and plasma propulsion and exotic fuels; sonics; space communications; space medicine; space navigation; and space physics.

Headquarters for the Division are at Sunnyvale, California, on the San Francisco Peninsula, and research and development facilities are in the Stanford Industrial Park in Palo Alto and at Van Nuys in the San Fernando Valley. Facilities are new and modern and include the latest in technical equipment. A 4,000 acre Division-owned static test base in the Ben Lomond mountains near Santa Cruz provides for all phases of static field test. In addition, flight test facilities are provided at Cape Canaveral, Florida, and Vandenberg AFB, Santa Maria, California.

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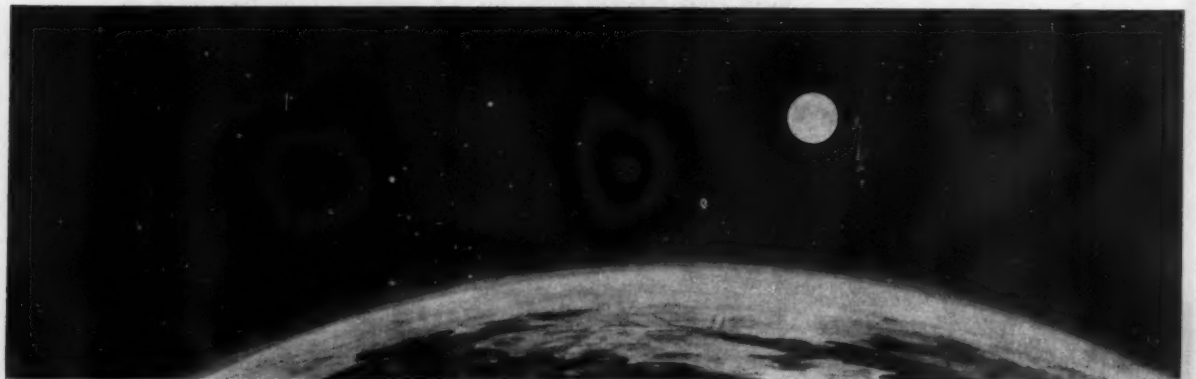

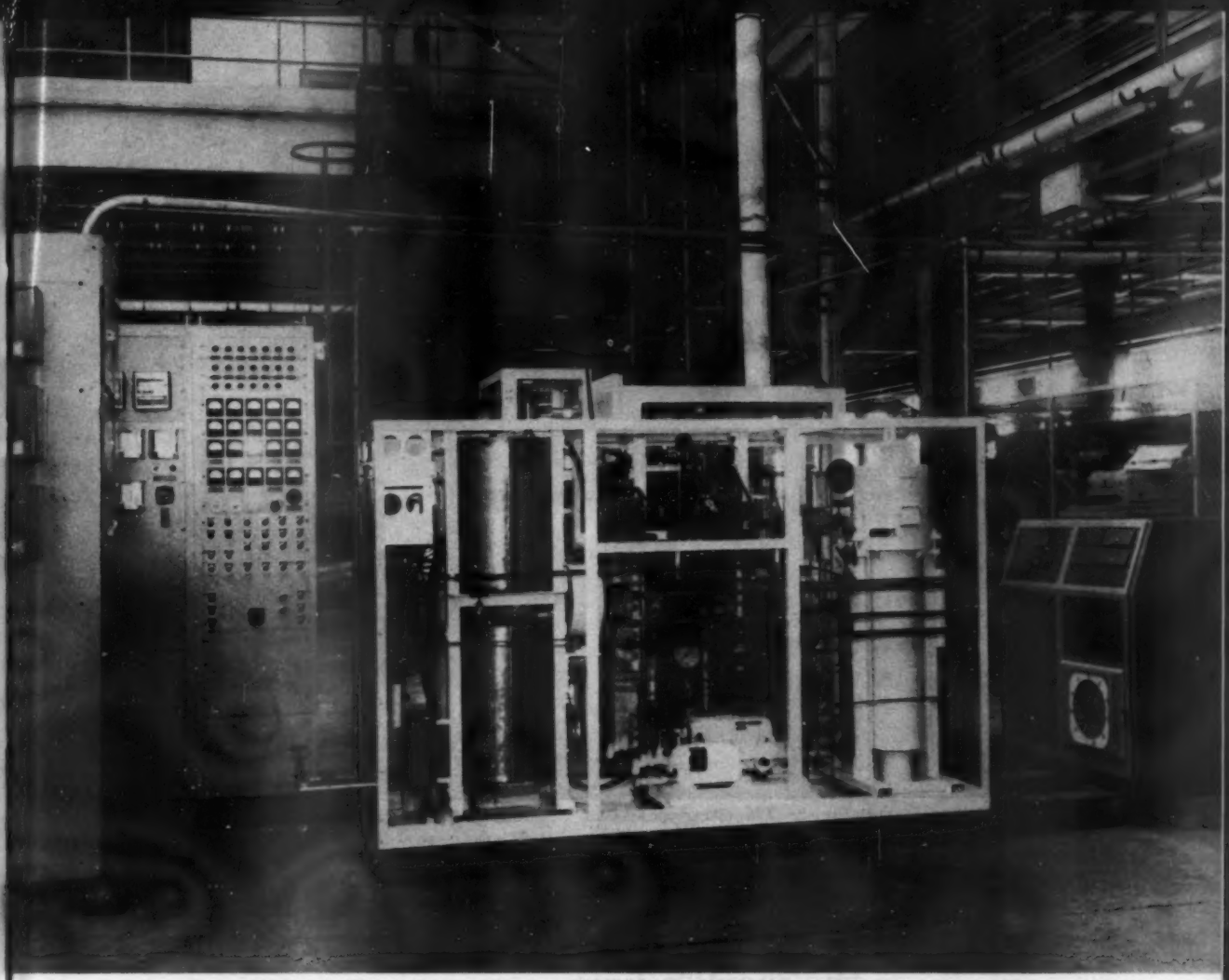

General view of components. Extreme right is data logger recording thirty-two points of flow, temperature and pressure. Asbestos covered line in rear is the in-pile line. The farthest section is that which will be inserted in reactor. Unit in center contains make-up pump, vacuum pumps and neutron detector. All units are in respective positions as they will be placed on the balcony of reactor.

TEST LOOP FOR NUCLEAR REACTOR FABRICATED AT LUMMUS' ENGINEERING DEVELOPMENT CENTER

The Lummus Company Engineering Development Center, Newark, N. J., recently completed the fabrication, assembly, test operation, and dismantling of a ¾" In-pile Test Loop designed and constructed for Westinghouse Electric Corporation, Atomic Power Department, as a part of the AEC Research and Development Contract AT-(30-3)-222. This loop was built for experiments in connection with irradiation of fuel element and control rod designs for the nuclear power reactor to be installed by the Yankee Atomic Electric Company at Rowe, Massachusetts. The reactor is being designed by Westinghouse for Yankee. Upon delivery to the Materials Testing Reactor at Idaho Falls, the loop will be installed and operated to simulate actual reactor conditions on fuel element and control rod samples.

The purpose of this experiment is to study the performance of the fuel element design and its resistance to corrosion under irradiation in plant environment. It is also intended to investigate the suitability of the control rod materials. In addition to this, during the first months of operation, a water chemistry stability study is planned.

Owing to the limited space available at the Materials Testing Reactor, the entire loop was constructed in two cubicles, an instrument panel, and a motor control center. All of the components other than controls were contained in these two cubicles. Careful planning was required to insure that all equipment would fit and that there would be no piping interferences. After assembly, the loop was operated at The Lummus Company Engineering Development Center to insure meeting of engineering specifications and reliability of components. After this operation and acceptance by the customer, the cubicles, motor control centers, and instruments were individually packed and shipped to Idaho Falls for reassembly by Phillips Petroleum Company personnel, who operate the Materials Testing Reactor.

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Now electronic quality control—a new way of precision-building a tire—has been added to the superior materials Goodyear puts *into* a tire. What it means is this:

1. Up to 25% more safe mileage—anywhere. Now, mixing of new chemicals and tread rubber is controlled by electronics. And the other major reason for Turnpike-Proved mileage—triple-tempered 3-T Cord (Rayon or Nylon)—is built into tires with the control of electronic eyes.

2. New whisper-quiet, cushion-soft ride. New chemicals permit us to soften the tread of our tires *without sacrificing mileage.* Because we have rubber that's softer, yet tougher, Goodyear tires now give you up to 25% *more* mileage than before.

3. New 3-way sureness on the road. Quicker starts—safer stops—better car control on turns. Again, this Goodyear advance comes not only from design factors, but also from the precision quality we get from *electronic controls.*

Without question, these Goodyear tires are the finest we've ever produced. Goodyear, Akron 16, Ohio.

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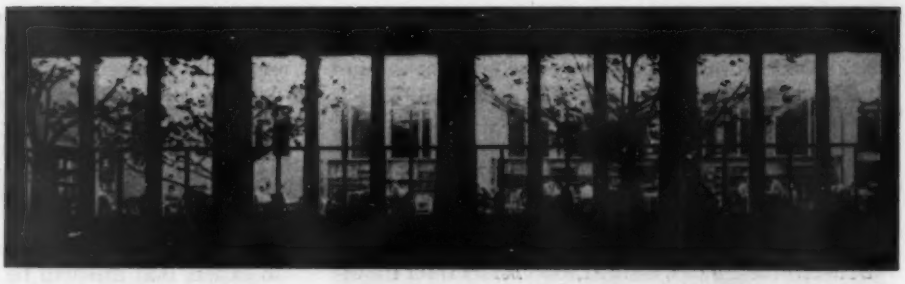
Trend Of Affairs



Fascinating Events In Solid Materials

A NEW Laboratory of Chemical and Solid State Physics has been created at M.I.T. It is directed by John C. Slater, Institute Professor, and the Departments of Physics, Chemistry, Metallurgy, and Mechanical Engineering are represented on its staff of more than 100 researchers and advanced students.

The modern concept of materials and materials research led to the formation of this laboratory. In it the basic knowledge will be sought which is needed to create advanced working substances. Both atomic age and space age requirements have increased the demands for such knowledge. Both plastics and transistors are examples of the products of materials research.

"Effective research in this field," says Professor Slater, "is of the utmost importance to the scientific and technological progress of our country."

Already the National Science Foundation has granted $599,200 to M.I.T. for studies to be undertaken in this field. Of this sum, $399,800 was for low-temperature and related studies, and $199,400 was for research in neutron physics.

The changes that take place at low temperatures in ferromagnetic, ferroelectric, and organic materials have become increasingly interesting to both scientists and engineers. The built-in magnetic properties of individual atoms in ferromagnetic materials, and the spontaneous electrical properties of ferroelectric materials, are being employed in computer components now and further applications seem likely. The new branch of science called cryogenics is based on the discovery that certain metals become superconductors of electricity at very low temperatures.

At times the atoms in the lattice of a crystal of solid material, like guests in the rooms of a hotel, rearrange themselves or exhibit new patterns of activity. These and other phenomena will be studied with an array of such techniques as x-ray diffraction, neutron diffraction, and nuclear magnetic resonance measurements.

For work in neutron physics, the Institute's new reactor and associated apparatus, including a polarized beam neutron spectrometer, will be used. Support for this phase of work previously was provided by the Office of Scientific Research of the Air Force.

Chu's Law of Student Aid

M.I.T. HAS loaned more than $5,000,000 at a nominal, noncommercial rate of interest to students to help them pay their tuition. The Institute was the first school to provide this kind of student aid on a large scale, and for 30 years has been able to say proudly that no worthy student was deprived of the educational opportunities it offered because of inability to pay tuition.

Thanks to the rate at which loans have been repaid, additional gifts, and the income from investments, the Technology Loan Fund has grown. But tuition has risen, too. In 1948, it was only $800 per annum. Next fall, it will be $1,500. Both the number of loans and the amounts loaned have been rising, and the withdrawals from the fund exceeded its income last year.

Lan J. Chu, '35, Professor of Electrical Engineering, plotted the figures for the last decade when he became chairman of the Committee on Student Aid this year, to see if he could find an empirical "law" relating these loans to tuition—and found that the annual need was proportional to the square of the tuition.

If Chu's hypothesis is used to predict loans in 1960–1961, one finds that they will total $910,000, and that if tuition is raised again, to, say, $1,700, in 1962, the annual loans will rise to $1,170,000. Last year they totaled only $682,000.

"The Technology Loan Fund," says the report of Professor Chu's committee, "has been well administered, has fulfilled its purpose in the past, and its assets now, including investments and loans outstanding, amount to about $3,268,600. If its capital is exhausted by further withdrawals for loans, it will become a truly revolving fund. The sum loaned each year, however, will be limited by its income . . .

"It is painful to think that the Institute ever will turn away a worthy student because of his inability to pay its tuition. It is inconceivable, in view of the increasing importance of M.I.T.'s educational services, and the plans for continuous improvement of its facilities and the environment that it provides for students, that the Technology Loan Fund will not be kept adequate to fulfill its noble objective in the future as it has for 30 years. The Committee strongly recommends, therefore, that steps now be taken to obtain annual replenishments to prevent exhaustion of the Technology Loan Fund."

Special Summer Programs

THE ROSTER of short courses to be given at the Institute during the coming summer looks like a tip sheet on some of the hot subjects in architecture, engineering, management, and science. This year's series includes 26 Special Summer Programs, to be given by Departments in all five Schools. Most will last for two weeks; the first one begins on June 14, and the last ends on September 2.

Between these dates, about 1,650 visitors from industry, government, and other schools will have registered for one or more of these intensive courses. Experience suggests that they will have come from nearly all of the 50 states and many foreign countries.

This year's programs include:

Theory and Criticism in Architecture and City Planning.
Inertial Guidance – Terrestrial and Interplanetary.
Modern Research Methods in Biology and Medicine.
Fundamentals of Adhesion.
Strength of Plastics and Glass.
Dynamics and Control of Chemical Engineering Processes.
Infrared Spectroscopy: Technique and Applications.
City and Regional Planning.
Estuary and Coastline Hydrodynamics.
Electronic Flash and High-Speed Photography.
Modulation Theory and Systems.
Noise Reduction.
Radar Astronomy.
Switching Circuits.
Scientific and Engineering Reports.
Industrial Dynamics.
Planning Marketing Strategy and Tactics.
Fluid Power Control.
Industrial Photoelasticity.
Modern Developments in Heat Transfer.
Strain-Gauge Techniques: Fundamentals and Applications.
Engineering Aspects of Solidification of Metals.
The Electron Microbeam Probe and Its Application.
Applications of Probability Theory to Operations Research.

For further information, write Professor James M. Austin, Director of the Summer Session, Room 7-103, M.I.T.

The Alumni Council's Meeting

BRIGADIER GENERAL Benjamin S. Kelsey, '28, USAF (retired), and Walt W. Rostow, Professor of Economic History, spoke at the 342d meeting of the M.I.T. Alumni Council on January 25 in the Faculty Club.

General Kelsey, who is Jerome C. Hunsaker Professor of Aeronautical Engineering this year, was formerly Director of Research and Development at the U.S. Air Force Headquarters. He emphasized the variety of situations which may confront the nation's military forces, and mentioned some of the developments now in progress, such as vertical take-off and landing, that can permit greater flexibility in the deployment of military forces in the future.

Professor Rostow stressed the needs for concern regarding the allocation of our national resources and for giving more attention to the country's productivity – especially if more effort is to be put into education, defense, and space exploration. Universities such as M.I.T., he concluded, must pioneer in research activity on broad fronts, in the hope that breakthroughs can be provided in older fields as well as in the new areas.

Edwin D. Ryer, '20, Chairman of the Alumni Fund Board, reported that the 1960 Fund had received $407,000 from 9,440 contributors, and has every reason to expect that this will be another banner year.

President Edward J. Hanley, '24, presided, and 171 members and guests of the Council attended.

Fellows From Harvard

THE SOCIETY of Fellows at Harvard has been "an extraordinarily favorable seedbed for the development of distinguished university teachers," President Nathan M. Pusey observed on its 25th anniversary. The young scientists, poets, historians, and linguists chosen for these fellowships are given three years of freedom to use Harvard's resources as they choose – and have contributed both to science and the humanities in a great variety of ways.

Six of this society's 155 former members now teach at M.I.T. They are Albert Bush-Brown, Associate Professor of Architectural History; Noam A. Chomsky, Associate Professor of Modern Languages; Peter Elias, '44, Associate Professor of Electrical Engineering; Charles M. Gray, Assistant Professor of History; Marvin L. Minsky, Assistant Professor of Mathematics, and Paul A. Samuelson, Professor of Economics.

Progress in Paleoecology

SIGMA XI's lecturer at M.I.T. and other New England schools this year is Heinz A. Lowenstam, Professor of Paleoecology at the California Institute of Technology. In his lecture he points out that skeletal remains of prehistoric animals have been the main biological source of information about the earth's early environment, and cites learning how cold or warm the oceans were before there were thermometers or humans as one of paleoecology's achievements. It is now possible, according to Dr. Lowenstam, to measure temperatures as far back as mid-Paleozoic times, some 350,000,000 years ago, and to "evaluate the history of sea water with greater confidence."

Note to Small Businesses

A SEARCH for jobs in small business concerns was begun this winter by 20 graduate students in the M.I.T. School of Industrial Management. William P. Mott, 3d, of Orinda, Calif., who is chairman of their informal organization, explained:

"Our objective is to seek out companies which are interested in men of ability. We are specifically interested in companies that possess a personally acquainted, close-working management group, yet are not limited to a maximum dollar volume of sales. . . .

"Any company interested in receiving résumés of our members can write *Business Search* in care of the M.I.T. School of Industrial Management."

1960 Ballot

IN ADDITION to its selection of Clarence L. A. Wynd, '27, to become the 67th occupant of the M.I.T. Alumni Association's Presidential chair, the National Nominating Committee has presented six further names to appear on the 1960 ballot, as follows:

For Vice-president, 1960-1962 – Thomas F. Creamer, '40, Vice-president, The First National City Bank, New York.

For members of the Association's Executive Committee, 1960–1962 – Randolph Antonsen, '35, Director of New Products Research, Godfrey L. Cabot, Inc., Cambridge; and John L. Danforth, '40, Vice-president and Director, Mechanical Engineering, High Voltage Engineering Corporation, Cambridge.

For nomination as Alumni Term Members of the Institute Corporation, 1960–1965 –

Bennett Archambault, '32, Chairman of the Board and President, Stewart Warner Corporation, Chicago;

Robert H. Winters, '33, President, The Rio Tinto Mining Company of Canada, Ltd., Toronto; and

Semon E. Knudsen, '36, Vice-president, General Motors Corporation, and General Manager of its Pontiac Motor Division, Pontiac, Mich.

The nominee for President of the Association, Mr. Wynd, is Vice-president of the Eastman Kodak Company in Rochester, N.Y., and General Manager of the Kodak Park Works. He is also Vice-president and Director of the Eastman Gelatine Corporation, and a Director of the Canadian Kodak Company, Ltd., Canadian Kodak Sales, Ltd., and the Ridge Construction Company.

Mr. Wynd is now an Alumni Term Member of the M.I.T. Corporation and the Institute's Honorary Secretary in Rochester. He has been a member of the Visiting Committee on the Department of Chemical Engineering since 1955, and an active member for many years of the M.I.T. Club of Rochester, of which he was President in 1953-1954. Mr. Wynd also has served as a trustee of the Harley School in Rochester and as Chairman of an Advisory Committee for Chemical Engineering at the University of Rochester.

He is a trustee for life of the Rochester Chamber of Commerce and was its president in 1957. He was a consultant to the Office of Production Research and Development of the War Production Board in 1944–1945.

Mr. Wynd is the nominee for President of the Association.

Radioisotopes Institute

RADIOISOTOPES have come of age, and now they belong in every college science curriculum.

To help put them there, the National Science Foundation and Atomic Energy Commission will sponsor several Summer Institutes in Radioisotopes Technology in June and July, 1960. One of them will be at M.I.T., under the direction of Gordon L. Brownell, '50, Assistant Professor of Nuclear Engineering. About 40 college teachers in the physical sciences and engineering, mostly from New England, will attend these sessions.

Messrs. Archambault, Winters, and Knudsen (left to right) are nominees for Alumni Term Members of the Corporation.

The Legend of Eli Whitney

MUCH of the credit for introducing interchangeable parts and starting American industry's growth long has been given to Eli Whitney. This was done fulsomely in a recent television drama. But less credit might be accorded to Whitney, and more to some of his contemporaries, if historians looked into the trend of affairs in those days more closely, Robert S. Woodbury, '28, Associate Professor of the History of Technology, suggested at this winter's meeting of the American Association for the Advancement of Science.

"There can be no doubt," said Professor Woodbury, "that what became by the 1850's widely known abroad as the 'American system of manufacturing,' had its origin in the first quarter of the Nineteenth Century and that its principal features were developed in the northeastern section of the United States. This American system included mass manufacture, by power-driven machinery, by machinery especially designed to serve a particular purpose, and by the use of the principle of interchangeable parts.

"The legend says that all this stemmed from Eli Whitney, but we actually know very little of what he really did, and other men were working along these very lines in the manufacture of arms at the same time. Certainly many other men contributed as much or more than Whitney, and evidence for their work can be found which is far more convincing than Whitney's boasting claims."

But why should anyone care now? Does it matter if school boys are led to admire him excessively?

Professor Woodbury thinks it does, because: "The history of our industrial growth is of first importance to our understanding of our American heritage. That industrial development cannot be properly understood without careful consideration of its technological basis. The true story of the 'birth of American technology' is, therefore, of prime concern."

A CITATION went to this design for the Riverview Redevelopment Project in Cambridge in *Progressive Architecture's* design awards program this year. The architect was Edwin T. Steffian, '21, and the rendering was by Marilyn Fraser, '55. The plan is for the redevelopment of two irregularly shaped acres along the Charles River for upper-middle-income apartments under stringent zoning rules.

Professor Woodbury's 6,000-word paper on "The Legend of Eli Whitney" will be published in full by the Society for the History of Technology in its quarterly, *Technology and Culture,* next summer.

Viruses and Cancer

BY NEXT SEPTEMBER, new laboratories on the eighth floor of the Dorrance Building at M.I.T. are scheduled to be completed, for work which should help to clarify the possible relationship of viruses to cancer. Dr. Salvador E. Luria, Professor of Microbiology, believes that viruses could cause certain types of cancer and will explore this possibility.

The laboratories will provide facilities for research into cellular biology with special reference to the relationship of individual molecules to the living cell. The cell is the starting point of life and is the key to a much deeper understanding of both life itself and the diseases that attack living organisms. Viruses are the puzzling agents that cause a host of diseases in man, animals, and plants. It is not really known whether viruses are living or not, since they are incapable of independent existence, but it is known that they can and do infect cells, existing in them as parasites.

Specific topics that will be stressed in the new laboratories will include tissue culture, animal and plant viruses, growth and differentiation in animals, and the biosynthesis of protein in the living cell. This work will fit in well with current programs in microbiology, physiology, biochemistry, and biophysics, and the post-doctoral medical research program under which doctors carry out advanced and specialized studies at M.I.T. At least one Faculty member and a number of graduate students will be added to the Department of Biology, and the staff of the new laboratories will number about 30.

"There is a tremendous need to go into cellular biology," says Dr. Irwin W. Sizer, who heads the Department.

"We want to study the size and shape of individual molecules and the role that molecules play in the cell. This is a major development in the study of cell biology and the life sciences at M.I.T."

This research program was made possible by a $100,000 grant from the National Institutes of Health, which will be matched with M.I.T. funds.

Stepping Out Was Tough

RED SMITH, The New York *Herald Tribune's* sports writer, recently devoted a column to the 101-day, 5,286-mile voyage of John R. Dahl, '58, who now works for the Evinrude Company in Milwaukee, and a 67-year-old California writer and photographer, John Edwin Hogg. They crossed America by boat (up the Hudson, down the Illinois, up the Missouri, and finally down the Snake and Columbia rivers) to Astoria, Ore., from New York City. When asked what was their toughest problem, Mr. Smith wrote, Mr. Dahl replied:

"Well, Mr. Hogg was 67 and I was 30—and girls in those age brackets don't run together much. Our biggest problem was double-dating."

Pegasus Cast in a New Way

A simple and inexpensive method of helping the sculptors has been developed and demonstrated in M.I.T.'s foundry

Alfred Duca produced this and other work to test the new casting method.

THE M.I.T. Foundry Laboratory has perfected a revolutionary technique – not in the field of science, but in art.

For more than a year, Alfred Duca, a Boston artist, has been a member of the Metallurgy staff, doing research in statuary casting. His association with the Institute resulted from a meeting with Howard F. Taylor, '46 (who holds the country's first endowed chair in foundry metallurgy), at a Duca exhibit in the Mirski Gallery of Art. Both Professor Taylor and the sculptor lamented the decline of art casting in this country, and were interested in reviving art casting for its intrinsic cultural value.

Casting has restricted American sculptors. The special techniques required are time consuming and expensive, and this country has few foundries for artists. There is only one in New England, and New York has only three.

The usual method of making a statue involves preparation of a wax or plaster replica the exact size of the finished object; sometimes a small model is made by the artist and a larger replica is made by a craftsman. Plaster is the more economical of the two media and, when it is chosen, the model usually is made in segments which are used as patterns. Traditional foundry practices are suitable, but extremely fine molding materials are required, and the work is done tediously by hand. The cast pieces must be cut, filed, shaped, burnished, and joined into place, and this requires a high order of craftsmanship.

"Young Americans have found that they could make more money working on mass production assembly lines than as apprentices or artisans in art casting," says Professor Taylor. "The consequence is that most casting of fine sculpture must now be done in Europe."

Pegasus went to the Kresge Auditorium to pose for The Review's cover.

M.I.T. and Al Duca jumped into this situation with zeal, supported in part by a grant from the Rockefeller Foundation Department of Humanities. One of their aims was to adapt various sculpturing media to traditional foundry techniques in ways which would enable an average foundryman to do the artists' work satisfactorily and economically. This would greatly extend the sculptor's freedom of expression. Now, after 10 months of research, they have a new, simple, and inexpensive method of statuary casting which can take its place beside 5,000-year-old methods.

It is actually a simplification and improvement of the so-called "lost wax" process of molding sculpture, which was first used in Egypt and China thousands of years ago. The lost wax method is used principally to make hollow castings. A plaster armature is first made, then coated with wax, which is sculptured and covered with plaster. The plaster mold is dried and hardened and

heat is used to melt the wax, which runs off, or is "lost." Molten metal is then poured into the mold, taking the place of the wax. When the metal has hardened, the mold is removed. This process is generally used only for casting bronze, gold, and silver objects.

The bronze Pegasus shown on the cover of The Review was made, not from the traditional model of clay, wax, or plaster, but from expanded polystyrene, the fluffy white material used by decorators and florists. This example of Mr. Duca's work is about 2½ feet high and weighs 400 pounds. It took him six weeks to whittle Pegasus with a grapefruit knife and small, coarse files.

This beautiful snow-white form was placed in a large flask, or box, in the foundry and surrounded with sand. Channels for guiding molten metal into the mold had been made of polystyrene and "glued" to the body of Pegasus, and molten bronze was poured into the mold at a temperature of 2300 degrees F. When this fiery mass struck the original statue, the polystyrene was vaporized, and beneath the mound of sand, 38 seconds later, stood a bronze Pegasus.

The advantages of this casting technique are several. It means that artists can design with more flexibility — a sculpture with complex surfaces will be no more expensive than a simple one. The process is fast and does not present annoying problems of fitting and joining. Aesthetically, too, this method has significance. A sculpture so produced has the organic vitality of initial creation. Its integrity is unquestionable; the model has become the statue.

The sparks flew on many occasions while Prof. Taylor and others were working with Mr. Duca on the new technique.

The Larger Learning

Life demands that the colleges emphasize human as well as the intellectual virtues

BY HUSTON SMITH

IT LIES within the nature of man to want for his children the best he can provide. Some of the provisions he can transmit are material. But there are other endowments, equally important but less external. These consist of the heritage of knowledge, skills, appreciations, and motivations that keeps each generation from having to start the human venture from scratch. This is where education enters.

In the past it always has been assumed that education should encompass values as well as skills. This is obviously true in simple societies. But in civilization, too, education historically has sought to impart values as well as devices. Thus today in America we find that almost every statement of objectives for primary and secondary schools will include moral development among its stated goals.

Higher education, too, has values to which it is deeply committed and which it seeks wholeheartedly to transmit to its students. But the values of American higher education are specialized. Catalogue statements to the contrary, the truth is that – with the exception of schools that are genuinely, not just nominally, church related – the American college today does not see it as its task to further *human virtues* as a whole. It restricts its responsibility to the *intellectual virtues.*

These latter are not inconsiderable. They center in an intellectual attitude which can be described, simply, by saying that it finds the mind's progressive disclosures of life and the world exciting as well as profitable. It wishes, therefore, to discover more of life and the world, and to see these more as they are.

Analyzed, this intellectual attitude yields the following specific intellectual virtues as ingredients:

¶ Intellectual honesty – the determination, insofar as possible, to keep personal bias from distorting one's vision of things.

¶ Scope of knowledge – other things being equal, a rich and varied stock of information renders life more interesting and competent.

¶ Dialectical agility ("sharpness") – not only should minds be informed; they should be able to work with their information nimbly, skillfully, and in orderly fashion.

¶ Aesthetic sensitivity.

These are the values in which colleges as institutions really believe. In promulgating them, however, teachers find that they entail several other values as supports. Chief among these are diligence, moral honesty, and academic freedom. If the students don't work, they don't learn. If they cheat or plagiarize, teachers cannot gauge their intellectual positions and needs. If teachers cannot teach what, and as, they feel they should, their effectiveness in transmitting the intellectual virtues is curtailed. Obviously diligence, fair play, and autonomy involve qualities which extend beyond the intellectual virtues proper, yet each is directly related to the intellectual life. If we use the phrase *academic virtues* to include these supporting virtues along with the strictly intellectual ones, we can

HUSTON SMITH, Professor of Philosophy, came to M.I.T. from Washington University in 1958. He has appeared in three series of educational television programs – "The Religions of Man," "Science and Human Responsibility," and "The Search for America" – which have been seen in many cities. This article is an abridgment of the first chapter of The Larger Learning, *a book edited by Dr. Marjorie Carpenter, to be published this year by W.M.C. Brown Co., of Dubuque, Iowa.*

say that it is this wider category that the American college is concerned to foster.

But this is as far as we can go. Public relations statements may profess the college's concern to develop moral character, citizenship, or spiritual growth, and certainly many instructors *as individuals* conceive their mission partly in these realms. But the general feeling among faculties is that virtues of this sort are not the responsibility of the college as an institution.

* * *

Why do they so feel? There seem to be five contributing reasons. Their relative weight varies from teacher to teacher; together they have led most teachers to the position just described.

1) The continuing force of *the Enlightenment view of man*. This view held, in essence, that reason is the key to the good life. Free the mind of superstition and ignorance, and it will prove both capable of discerning the good and persuading the rest of the self to follow it. Those who hold this view are not morally disinterested. They simply believe that the intellectual virtues provide the best leverage for moral growth. Jefferson was their American prototype.

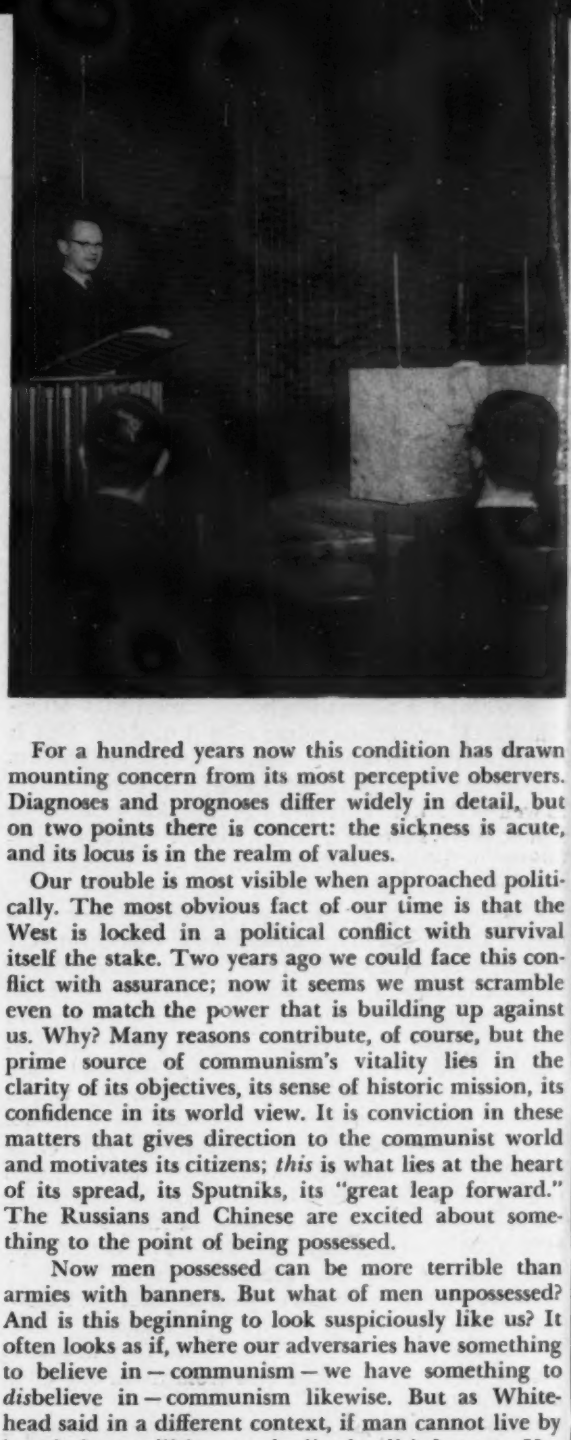
2) The belief that *all values are relative*. Various current doctrines of philosophy and the social sciences have created an impression in the academic mind that values are arbitrary in the sense of there being no universally valid standards by which to judge better from worse. Such a view obviously reduces the urgency of value instruction.

3) *The cult of objectivity*. History and everyday experience are replete with cases in which men's preferences distort their view of the facts. And since the discovery and transmission of truth are education's commission, the less education gets entangled with preferences, it is argued, the better it will be able to perform its appointd task.

4) *Division of labor*. This viewpoint accepts the importance of values and their need for special nurture; but it denies that the place for such nurture is the college. Complex societies require division of institutional function. And in our society, home and church look after moral values; the school, the intellectual ones.

5) *Respect for autonomy*. Our times are witnessing mass onslaughts on the individual, all aimed at trying to make him over from the outside. Let us keep one corner of this crowded world free of such calculated aims. Grant that left to shape their own values, some students will emerge worse than if they had received more direction. But such casualties are small compared with the loss of freedom, individuality, autonomy, and subjective selfhood which must result from any effort to imbue students as a mass with standardized values, however noble these may be in their own right.

There is so much truth in these positions that even if we believed each needed some qualification we might be tempted to consider their combined weight overwhelming. We might well accept this conclusion and leave higher education to its academic values exclusively were it not for one fact. That fact is the present condition of Western man.



For a hundred years now this condition has drawn mounting concern from its most perceptive observers. Diagnoses and prognoses differ widely in detail, but on two points there is concert: the sickness is acute, and its locus is in the realm of values.

Our trouble is most visible when approached politically. The most obvious fact of our time is that the West is locked in a political conflict with survival itself the stake. Two years ago we could face this conflict with assurance; now it seems we must scramble even to match the power that is building up against us. Why? Many reasons contribute, of course, but the prime source of communism's vitality lies in the clarity of its objectives, its sense of historic mission, its confidence in its world view. It is conviction in these matters that gives direction to the communist world and motivates its citizens; *this* is what lies at the heart of its spread, its Sputniks, its "great leap forward." The Russians and Chinese are excited about something to the point of being possessed.

Now men possessed can be more terrible than armies with banners. But what of men unpossessed? And is this beginning to look suspiciously like us? It often looks as if, where our adversaries have something to believe in — communism — we have something to *dis*believe in — communism likewise. But as Whitehead said in a different context, if man cannot live by bread alone, still less can he live by disinfectants. Unless we succeed in firming up a core of values in which we as a people believe as fully as the communists believe in theirs, we stand well to lose this struggle.

* * *

Purely political considerations, then, force us to ask whether higher education's exclusive attention to intellectual and academic values is adequate. But the matter should not rest here. For though the political argument is a powerful one, in the end it is a poor one. The real reason for questioning the universities'

current stance toward values is not that communism requires it. The real reason is that life requires it.

The pertinent points, here, are three:

¶ Some core and hierarchy of value convictions is essential to human well-being. To be totally at sea with respect to values, continuously and acutely in doubt as to what is better and worse, is intolerable.

¶ If some value structure is essential to man's well-being, it is equally true that certain structures are superior to others. A decade ago anthropology, psychology, and philosophy might have challenged this statement. Today advanced thinking in these fields tends to confirm it.

¶ If it is important that men have values, and if it is important that they have certain values rather than others, it is equally important that these values pervade the culture as a whole.

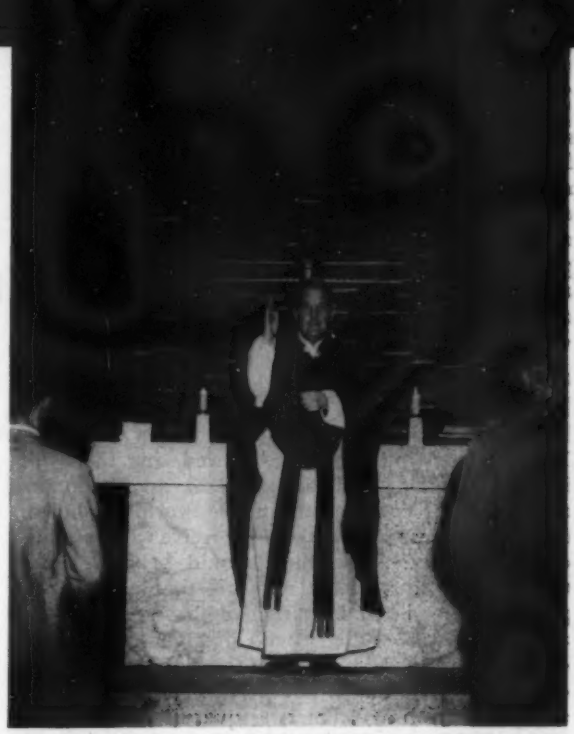
Overwhelmingly men and women derive their values from their culture. We have outgrown the exaggerated individualistic approach to physical welfare altogether with regard to health and to an appreciable extent in economics. No one doubts that health is a communal problem, that unless there is collective responsibility for sanitation, water purification, quarantine, and at times innoculation, the individual is helpless. Any teacher who championed letting students work out their own health conditions would feel a bit foolish; we even compel Christian Scientists to take physical examinations. Yet somehow when we turn to other values their social character drops from sight. The individual student suddenly becomes omni-competent, and *laissez faire* and rugged individualism carry the day. Alas, the truth lies far from such notions. Basic, deep-lying values are closer to the air we breathe and the water we drink than the artifacts we privately erect. Let water become polluted, or air, and individuals are defenseless.

* * *

Not only communism, then, but life itself requires that we re-examine the five reasons that currently persuade teachers to restrict their concerns to academic values to see if, in the face of our needs, they still appear sufficient.

1) The *Enlightenment view* maintains that reason is an adequate guide to the good life. Yet the strongest currents of Twentieth Century thought, even academic thought, challenge this hypothesis. No one argues that reason is irrelevant to the good life. But can it, unaided, spot which values are right? In other words, are values objectively demonstrable? And, if so, is reason's control sufficient to dispose men to follow its goals in the face of temptations to the contrary? On the whole, evidence seems to answer both questions in the negative.

2) *Value relativism.* How many students have concluded from this phrase that floats so freely over college campuses that one thing is as good as another? Yet frontier work in anthropology does not point to unqualified value relativism. "There is a growing tendency . . . for anthropologists to [try] to find out what moral principles are universal because universal conditions of human living give rise to them," says Robert Redfield, adding, "I am persuaded that cultural relativism is in for some difficult times." Similarly strong tides against value relativism are now apparent in psychology and philosophy as well.



3) *The cult of objectivity.* Understood positively as the determination to keep personal bias from distorting truth, objectivity is invaluable to the intellectual quest. Yet some fields require empathy and allied qualities of understanding. Peguy tells us the true historian should be not *desinteresse* but *passionne.* Even where values are not essential to vision, and can obstruct it, need they do so? It is simply not true that teachers who have the weakest commitments see things clearest. What education needs is neither teachers without commitments nor ones who try to check their commitments when they step onto the campus. It needs teachers who have the sense to see where convictions are likely to refract the truth and who will take pains in such cases to try to compensate for their refraction.

4) *Division of labor.* If to be concerned for values and their transmission required that teachers subtract time and attention from subject matter, the "division of labor" plea might stand. But does it require this? I can only report that the teachers who did most for my values did most for my understanding as well. For it was not as if their concern foreshortened their learning; it infused it with blood and sap – the trees of knowledge and life growing together. As we come to think of it, there seems to be something like an inbuilt protection against values detracting from subject matter, for to the extent that teachers go out of their way for values, simply dragging them in, they moralize and preach, and such devices never succeed. They boomerang.

5) *Respect for student's autonomy.* This is certainly a valid ideal. But obviously it cannot mean that we should not try to influence students at all. Where, then, is the line between legitimate influence and indoctrination? The point of division can only be in terms of the worth of the influence to the student him-

self. If the values conveyed increase the student's usefulness to the teacher, the economy, or the state primarily, and if free discussion is restricted and relevant data are prescribed, the student has been indoctrinated. But if there really are values which are indispensable to the well-being of the student himself, his autonomy will be infringed if these are denied, not if they are supplied. Not to care about imparting such values is not to care about students.

* * *

Enlightenment philosophers believed, and their spiritual descendants still believe, that an uncontaminated reason looking out on the world of human doings and consequences would perceive without much difficulty how sensible men should behave. Unfortunately the situation is not this simple. Evil men prosper; the wicked flourish like the green bay tree and the good die young, often enough at least to make such sayings proverbial. What empirical facts could one hope to find that would persuade the horse trader always to give his customers a square deal? The truth is that if this is a moral universe it is not so obviously one that a college student is likely to discern the fact singlehandedly any more than he would be likely to stumble onto Newton's laws. From a reasonably clear-eyed but uninclined observation of the moral scene, he would be likely to conclude almost nothing. But let him get hold of a postulate; let him be brought to the conviction, for example, that "he that seeketh his life shall lose it" and—here is the difference between theoretical and practical reason—let him work his life into such a postulate and begin living according to it, and behold, the facts of experience will confirm it, even as they do Newton's laws.

This is why Plato says the student needs to be helped in this area; he needs to be educated in poetry and music for then "when reason comes, he will greet her as a friend." It is why Aristotle says that only pupils trained in "ordinate affections" will be able to perceive the first principles of ethics.

There is one other point on this matter of autonomy and indoctrination. Teachers may hestitate to influence student values, but we should never forget that there are other agents in society that have no trace of their squeamishness. Propaganda dispensers in the true and dangerous sense of that word din our students' brainpans from morning to night. No wonder we retreat, determined to have no part of such exploitation. But if true values do exist, not to help our students discover them is to leave them prey to lesser ones.

* * *

Finally, I want to mention briefly three great questions that follow if the thesis that has been stated is accepted. If there are values other than the intellectual-academic toward which the college should assume responsibility, what are they, can they be transmitted, and if so, how?

First, what are they? Despite all our talk about the relativity of values, I doubt that there is much dis-

agreement on this question. Aldous Huxley in *Brave New World Revisited* speaks of the need for a set of generally accepted values based on fact and comes up with the following:

> The value, first of all, of individual freedom, based upon the facts of human diversity and genetic uniqueness; the value of charity and compassion, based upon the old familiar fact, lately rediscovered by modern psychiatry, that . . . love is as necessary to human beings as food and shelter; and finally the value of intelligence, without which love is impotent and freedom unattainable.

This statement does not close the question, but I am not concerned here to carry it further. Let me say only that I do not see this question as the difficult one.

The next question — can values be taught? — is more vexing. Life's opening years are so important for the structuring of personality that it may be doubted whether anything important in value redirection can occur thereafter. Yet there are points in the college experience where things appear to happen; and this intuition forbids us to let this question go unpursued.

Finally, how should values be taught? Happily, we are not entirely in the dark as to how students may be helped to discover and to internalize values. We know that example and habituation are crucial — and a campus ethos, a "style of life" embodying judgments, implicit and expressed, as to what a given community of scholars considers appropriate is important.

There are topics I cannot here expand. I hope only that the reader may share my feeling that they are a fascinating and, more importantly, a crucial set of issues. For they are concerned, as Plato put it, "about matters which to know is honorable and not to know disgraceful; to know or not to know happiness and misery — that is the chief of them. And what knowledge can be nobler? or what ignorance more disgraceful than this?"

New Demands in Engineering Education

Today's student must be prepared to cope with greater changes than his predecessor, and needs the guidance of a professor who has real insight into the new fields

BY HAROLD L. HAZEN

HAROLD L. HAZEN, '24, Professor of Electrical Engineering and Dean of the Graduate School at M.I.T., spoke at a Conference on Scientific Manpower during the recent meeting of the American Association for the Advancement of Science. This article was drawn from that address.

OUR SCIENCE and technology have become very sophisticated. Even more important, the rate of change of sophistication and complexity is very large, and over the recent decades this rate has been increasing rapidly. The implications of extrapolation become almost overwhelming. How can we, in the brief span of a few years after high school, prepare young people to join the professional ranks and to pick up their share of work, contributions, responsibility, and eventually, leadership?

That a serious problem in education is involved is clear. This problem of coping educationally with "new technology," of course, is not new; technology has been growing continuously since its inception. Each new element of growth from a new impact of science, and invention, a new art, or the emergence of a new application, has called for a corresponding response in the education of new recruits to the profession. Yet we sense that in some way today's situation is different from that, for example, at the turn of the century.

In 1900 a four-year undergraduate engineering program of elementary classical science, and some introduction to the art of engineering, provided an adequate foundation for the following 40 years. Our 1900 graduate, of course, had to be prepared to learn about new developments, and to add to his scientific preparation, but in a way that appears rather simple in retrospect. The 1965 graduate must be prepared to cope with far more radical changes if the obvious extrapolations of the past two decades have any validity. If he is to keep up with his profession and exercise leadership he will undoubtedly have to turn student and learn, during his professional life, not merely a few increments or extensions to fields learned as an undergraduate, but rather some entirely new field that may not yet have emerged from the research laboratory. Indeed, he may have to learn not one such new field, but two or even three at successive intervals during his career.

The recent rate of emergence of new science and its engineering applications imposes an entirely new level of demand upon the educational process — in developing the capacity to learn, and upon the character and quality of the intellectual foundation. Indeed, the whole scale and the dimensions of the demand for new learning that these rates of change impose are so greatly different as to make the new demands on education essentially different in kind from those of former decades. As never before, we must emphasize, not merely learning, but more importantly, learning how to learn.

The Profession's Foundations

So let us ask ourselves how we would characterize an engineering program for the next decade that will be useful to the 1970 graduate who expects to practice engineering from then until the year 2010. What kind of educational experience will best serve the purposes of this neophyte?

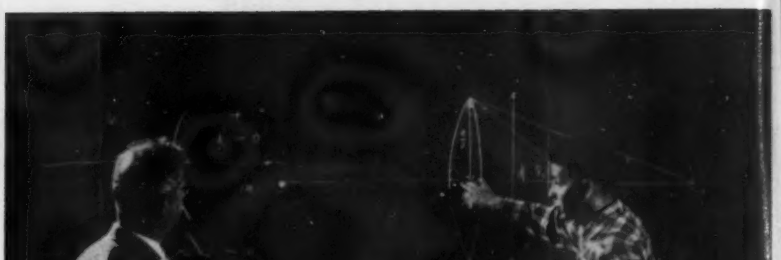
One of the foundation elements of an engineering education that is being increasingly recognized as of first-order importance, not only culturally but practically, is general education. By general education, I mean a serious introduction at the college level to our civilization, our culture, and the world of the mind and of values, by way of some challenging experiences in the humanities, in the social sciences, and in the natural sciences. This civilization and culture cannot be that only of contemporary America or the Western World; it needs to provide far wider perspectives in both time and geography. The engineer's attitudes and awareness can no longer be provincial. Wisdom, never in oversupply, is recognized as increasingly vital above and beyond intellectual competence. More than ever before, the engineer must be a well-educated person.

A second foundation element of an engineering education above and beyond general education, which for the engineer naturally would include strong basic science,

is the emphasis on science at a more advanced level, and with some applied flavor, in what we may call engineering science. This element of an engineering education always has been important.

It is even more important for the future. But beyond that, the outlook and quality of this education face new demands because of the future requirements faced by our 1970 graduate. In mathematics, for example, our new engineer must go well beyond the calculus and differential equations of my undergraduate days with their problem-solving emphasis. Our engineering student of tomorrow must give far more attention than we did to developing some appreciation of the methods of thought of the mathematician and of the rigor with which he examines, validates, and indeed develops new areas of mathematical thought. The mathematicians — not the engineers — are still going to produce the new mathematics; but increasingly the engineer must be prepared to communicate knowledgeably, and to work with his mathematical colleagues in order to understand new areas of mathematical endeavor, because these have become important in engineering. To do this, he must have at least some appreciation of the character of mathematical thought.

The same kind of outlook will be required in the experimental sciences. The engineer is not about to become a physicist or chemist. But the good engineer inevitably is being drawn closer and closer to his science colleagues. One example illustrates the point: A low-noise amplifying element, embodying a crystal of ruby operated at an absolute temperature of four degrees Kelvin in a helium cryostat, in order to achieve extremely low noise levels, and thus permit detection of an unprecedentedly low level of radio frequency power, sounds like a perfectly good piece of physics research laboratory equipment. But it enters the realm of engineering when it is installed and operated out in the weather 100 feet above the earth at the focus of an 80-foot diameter parabolic radio antenna to grasp the greatly increased radio and radar ranges thus opened up. This example is merely one of hundreds that can be cited today, to suggest that the science



foundation in engineering education faces major new demands of rigor, of depth, and of breadth.

Evolutions of Thought

Another characteristic of the science foundation of engineering has also been clearly evolving in recent years. This is the intermingling, interacting exchange increasingly occurring among the conventional engineering fields. For example, our teaching of the dynamical behavior of lumped-parameter systems is beginning to recognize the mathematical unity among the dynamics of discrete bodies, fluid systems, electric circuits, electromechanical elements, and chemical processes. We can be grateful to the field of servomechanisms and feedback control for forcing to our attention the educational gains that accrue from freely striding across the boundaries of these previously separately developed fields.

In the continuum, that is, phenomena involving extended distributions in space, or field phenomena, the educational exploitation of the basic mathematical similarity of electric, magnetic, thermal, elastic, and fluid-flow systems has great potential to extend intellectual horizons and deepen understanding. Thermodynamics similarly takes on far greater intellectual significance, as well as greater practical utility, when it is concerned broadly with the fundamental study of energy, its transformations, and its relation to the status of matter generally in a variety of fields involving chemical, phase, electric, and mechanical phenomena, than when it is restricted merely to sufficient theory to permit calculations on a few conventional kinds of heat engines.

In a somewhat parallel way, a fruitful new conceptual synthesis relating a wide range of phenomena appears to be evolving under the general heading of transfer and rate processes. This concept of transfer and rate processes brings together for common mathematical analysis and study a wide range of such diverse phenomena as transport of matter, momentum, and heat, including chemical reactions. Similar and major cross-fertilizations and interactions in thought processes are also occurring in other areas, such as materials, and information theory, and information processing.

These evolutions of thought have been emerging during the last few years in response to the urge for more generality, greater unity, and deeper insight, as well as economy of time, in this "second-time around" study at the engineering-science level of the mathematical and physical sciences by the engineering student.

A third foundation stone for engineering programs of the future is the introduction of the student to the engineering method, or what now is often called engineering synthesis and design. When rates of technological change were less, we suffered less from outdating when we taught the specific art of engi-

neering. Under present conditions such art is at least obsolescent when it is taught, and completely obsolete before the graduate can try to use it. We therefore are discarding the teaching of specific art as educationally unsound, and instead stressing methods of thought, that is, the methods by which new problems are approached, by which their essential elements and components are identified and analyzed, and by which valid solutions are synthesized. All these involve original thinking, exercise of judgment, and decision making.[1]

Emphasis is also being given to what has been called the "open-ended" treatment and attitude. This contrasts with the "bounded" treatment which presents a subject as if it were sufficiently well understood so that our task would be done when we mastered it. The open-ended attitude, emphasizes the questions that remain unanswered, the areas that are still to be explored, and the limitations upon our existing knowledge, thus challenging and beckoning the student on. This impresses upon the student the vital fact that learning is an ever-continuing process.

These foundation stones make *only* a foundation unless they serve to suppport creative activity, that is, the achievement of new devices, of new and better solutions to problems, and of new knowledge and art.

The Levels of Learning

Can we do all of this in four years, or must we seriously consider at least an additional year? This question is as old as American engineering education. Following World War II a few schools did adopt the five-year program. The idea has not spread, however, and I see no significant trend in this direction. The consensus of judgment seems clear that the development of intellectual power, of scientific and engineering discipline, of courage and insight to attack new problems, of breadth of outlook and sound judgment in their solution, rather than encyclopaedic grasp of subject matter, is the fundamental objective of an undergraduate experience in engineering education. The conviction is generally held that the bachelor's degree at the end of a good and continually evolving four-year undergraduate program is a valid and useful termination for this first stage.

Graduate study worthy of the name, even at the master's level, calls for aptitudes and a quality of mind that will benefit by more arvanced and more demanding formal study. At the graduate level there are, and should be, opportunities for several kinds of student interest.

There is the student who wants to go somewhat further in the areas opened up by his undergraduate work. He would like a little more mathematics, perhaps more physics, and wants to examine at a somewhat more advanced level some of the newer developments. Another student may want to go somewhat further, in a two-year "engineer" program available at some schools, aimed essentially at the development of more technical competence and insight in solving technically sophisticated, practical engineering problems. Then there is the student whose aptitudes and motivations urge him toward the more creative and scholarly kinds of activity associated with research or academic activities. He is the doctoral man for whom the demand is very great, both from industry and from our engineering schools. Whether he feels attracted to industry or to academic activities is more a matter of his personal interest than of any special educational or intellectual attainments. He is the man who likes to probe deeply, to understand profoundly, to work on problems of high intellectual challenge, to explore new ideas and develop new knowledge, and to be associated with students and colleagues of like interests and qualities.

Graduate work, in engineering especially, raises the question of the residential program versus the part-time study associated with employment in industry. Although both are useful, they serve different purposes. Part-time advanced study can contribute to knowledge and skills in specific fields; full-time residential graduate study has an objective above and beyond this. Just as the residential undergraduate college exerts an over-all influence on the development of the undergraduate extending far beyond mere instruction in subject matter, so full-time immersion in the work and environment of the strong residential graduate school produces changes in the graduate student influencing his whole outlook and attitude. This is the real function of the residential graduate school.

The Faculty Problem

The anticipated growth in engineering student numbers will require growth in financing, in

(Concluded on page 42)

[1]A stimulating exposition of these trends in thinking among engineering educators will be found in the Report on the Engineering Sciences, American Society for Engineering Education, *Journal of Engineering Education*, 49:33-91, No. 1 (Oct. 1959).

Why Do Good Men Fail?

Well-recommended, good students sometimes make poor showings at M.I.T., for reasons that epithets neither explain nor remove . . . here are some explanations

BY M. BRYCE LEGGETT

With Illustrations by Henry B. Kane

M. Bryce Leggett, '40, is Assistant Director of Admissions at M.I.T. He has worked in recent years with many students who came to the Institute highly recommended, yet failed to do well. Here are his "guesses" – in an article especially written for M.I.T. Educational Counselors – about the reasons for the difficulties that some promising men run into at M.I.T.

WHILE the Educational Counselor may be mystified when the Admissions Office turns down the boy whom he has recommended highly, he is probably even more at a loss when the really good-looking fellow he interviewed fails to do well after admission. In this case, the "pros" at Tech have agreed that the boy is good; in fact, they have turned down other "qualified applicants" in order to admit him. What has happened? What or who went wrong?

As the result of asking these questions about (and to and with) a group of freshmen who became involved with me in a special advising program – a program now integrated into the activities of William Speer, the Associate Dean for Counseling – I have some guesses as to answers. There are some general categories of response that can be listed. But there do not seem to be any clear-cut, immediate steps we can take to avoid admitting these fellows and I am prepared to plead that such action, if we were skillful enough to know how to do it, might constitute a cure worse than the disease.

One frequently hears the comment that the fellow who fails in his first year is lacking in inherent ability, is inadequately prepared, or has ineffective study habits. These are rarely the real reasons. The required tests are aimed at measuring ability as opposed to memory; they resemble not at all the TV quiz show pattern. It is almost impossible to get results too far from a valid measure of aptitude (which is what the tests are designed to measure and which is what they are called). It is even hard to make them come out too low; or why do smart students being pushed the wrong way and looking for an out so seldom do poorly on them? Test sophistication or "quizmanship" doesn't help either.

Inadequate preparation is not the answer. The student with ability can and does overcome any deficiencies in his schooling; the boy from the one-room high school (we have a few) can be up even with the boy from the most highly rated secondary school in a term or two. He recognizes his weak areas (and these are comparative, not absolute) and works harder on them. In cases where it has been insisted that the sole reason for failure was poor preparation, a second round in a specialized prep school hasn't resulted in a better record at M.I.T. Conversely, the best formal school preparation will not make up for lack of ability and certain other qualities to be discussed later.

The question of study habits is a tougher one. There is some evidence that entering students in most colleges do not study effectively. They begin at the top and plod to the end; they concentrate on the trees without ever deliberately trying to identify the forest first; they are systematic to a fault. But this can be remedied. Most of our students do it themselves and rather quickly. They report increasing "efficiency" within a couple of months and, to their amazement, the decrease in "goofing off" time doesn't account for all the improvement. I doubt that any of the students we admit are incapable of developing good study habits quickly – if they "want to."

If they "want to" – this is the important criterion as I see it. Let's say that those who fail at M.I.T. all fall in the category of difficulty in this area (except for the few for whom we've ignored the practical limits because we believed that motivation was high enough to overcome a marginal ability).*

But having made that glib comment, we are faced with the real question about our failures. Why did they not want to do what had to be done to get satisfactory grades here? Laziness? Weak or spurious motivation? Personal problems? Something about M.I.T. as it is? Or as it seems to be? All of these are observable reasons for failure, and there are undoubtedly more.

*Incidentally, no matter where you put the margin, there are always marginal cases.

Laziness is an easy term to apply. It is not so easy to justify. The boys we admit should be able to carry the academic load we place on them and have some time left for other activities in addition to eating and sleeping. This is our aim, and most do. So one asks what else he is doing with his time, where is he putting his effort, and why? Are his other activities contributing to him as a person? Are they an essential part of his growth to maturity? Ought they, in fact, be *for him* more important right now than studying? Sometimes the answers are unequivocally "yes!" Is this laziness? Or, again, is his lack of attention tied with those questions of motivation which come next in this outline? Generally, what is dubbed laziness is nothing more than the symptom — when it is anything more than a convenient term of opprobrium with which to flail a youngster because it's easier to flail than to think.

You Have To Be Gung-Ho

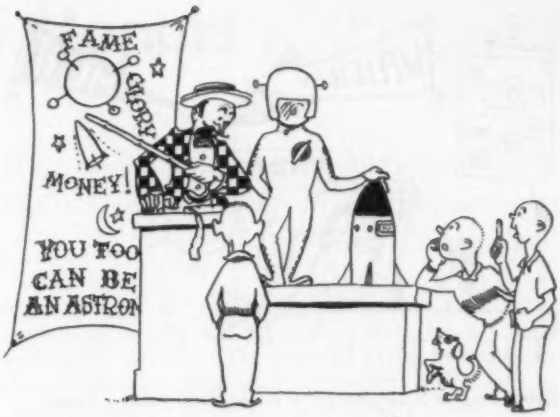
So to motivation. My student friends tell me that "you have to be 'gung-ho' for the things we study here to come out on top." And this is probably true. The student has to see in his studies a source of excitement and personal commitment in order to take the pace. He may see the job he wants; we hope he sees the mind he wants.

Can't we feel sure that a student who enrolls in M.I.T. has adequate motivation? Not yet. This is one of the areas where guidance and counseling of high school students can help, but we have no sure measures or tests to help us yet. There will be the student whose motivation is doubtful; he isn't sure what he wants to be. He is "pretty sure" and he won't admit to people with an M.I.T. position that he is doubtful, especially since he wants to get in. He may never have had to work hard enough at any subject to realize that it is less pleasing than another. This is a problem we must expect when we are attracting top-level minds.

Perhaps a student is exposed to rigorous and adult work in history or the social sciences or literature for the first time, after he enters M.I.T., and finds that when these subjects are presented with the same intensity as are the sciences they are more interesting than science or mathematics. If he does find this out, he may fail to do well here simply because he is not able to devote most of his time to these subjects. Interestingly enough, a frequent indecision of this kind is between physics and music as vocation; the resolution falls about an equal number of times on each side. Here a controlling factor, but not an adequate one for the school boy facing this problem, has been the anticipated relative income from the two professions.

Another spurious motivation seems to be the result of our post-Sputnik insistence on our need for scientists and engineers. The student who wants to be something else is sucked in by the drum-beating and decides to try it. He's serious, he's sincere about it; it just doesn't pan out.

Then, too, there are misconceptions about the term engineering as we use it. The fellow who wants to tinker as an expert and push a slide rule through someone else's equations may well think that this is



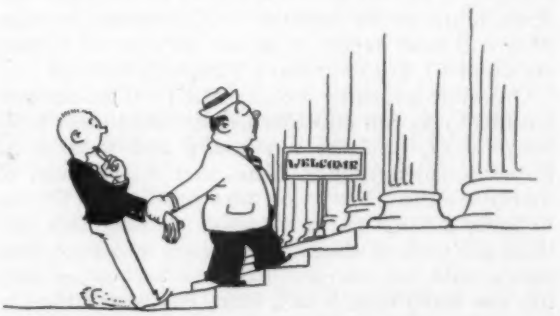
Sometimes the drum-beating sucks in the wrong young men.

engineering; in many quarters, it is. But at M.I.T. this fellow finds himself in a two-year math sequence that is on the road to a Ph.D. in math and in a parallel sequence in physics that is the start of the Ph.D. physics program. *And,* he's expected to "do engineering" in this fashion, with these same basic tools and, more importantly with the pioneering spirit of modern scientific advance. He has the choice of revising his idea of engineering or of being unhappy. If the latter, he may fail.

It would be less than candid to omit mention that the motivation of a few is solely to get into M.I.T. This doesn't give the drive needed to do good work after the student is here. A weak motivation, and one that can be inadequate, is to get the prestige of an M.I.T. degree. And, unfortunately, there is also *imposed* motivation, that really belongs to the parent but has been induced in the boy through those subtle and important relationships between parent and child. A boy who has only this to push him on doesn't have a chance to do well.

Sometimes, I think with hindsight, that we have admitted a parent and flunked him out. The tragedy is that the boy has had to do the work and bear the shame and, at least in part, he has had to cope with the heartache.

There is also the romantic student. My first encounter with this type was in my first class: "I want to do research in leukemia, but why should I grub around with quantitative analysis?" We still have these on occasion: it is usually space these days.



And sometimes it looks as though we had admitted a papa.

Being true to Susie can get a fellow into quite a bind.

Motivation, then, is important and lack of proper motivation can account for failure to do well. But, what about the student whose inherent ability is high, whose preparation is first class, and whose motivation is undeniably strong and true? Sometimes, he fails, too.

Adjustment Problems

And so we move into the area of personal problems. This is where, in general, the skill and insight of the trained counselor are most valuable and where the layman makes his contribution by being a trusted friend and by being willing to concede that there is a possibility that something very real is here and that simple epithets like laziness, poor study habits, etc., aren't necessarily applicable.

In an age weaned on Freud, with every man a psychoanalyst, it should not be necessary to insist that not all personal problems are apparent in their essential nature to those who have them. The personality has its own deviousnesses. But, let's look at some of the many things that can happen to a fellow so that his efficiency at study is impaired.

He can, of course, be unhappy with M.I.T. Sometimes this is because, as a community, we are quite unlike what he has known and feels congenial in. He may find that our competitiveness (which I think is more often just able minds working hard than aggressiveness) is too much for him. He may (and I've heard this said by students) be aware that we want to educate him broadly and be disturbed that we are making him change too fast. These are, I think, possible reactions of some students to M.I.T. as it is. There are all sorts of reactions to M.I.T. as it is thought to be, but in objective fact is not. Most students adjust to the Institute or any community they join, and most expect to adjust (at least when they are rational). But some can't. They may well fail.

Or, while adjusting well to M.I.T. as he finds it, a student may run into concomitant adjustment problems—away from the community and patterns he formerly called normal. This isn't always easy, or dramatic either. The fellow who promised to be true to Susie, the best girl in Podunk, and now finds that there are scads of chicks at Wellesley who have Susie beat a mile, but who still has Susie back home waiting and being true, is in a bind. He doesn't want to hurt Susie, but, well—how does he grapple with this and do all those problems in calculus at the same time? Funny? Not for him. This is deadly serious. A more obviously serious possibility is the drastic challenge which Twentieth Century science can give to a philosophy or religion that was learned at home and is a source of security. Some fellows cannot resolve this and do good academic work at the same time.

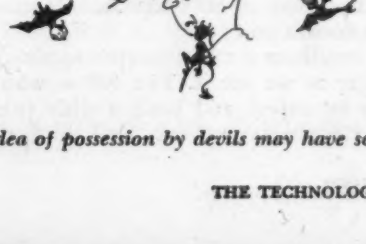
Another personal "adjustment" problem may arise more frequently in the future than it has heretofore because a larger portion of our students now come to us with extremely strong academic records. A few of these will be uncomfortable with their first set of grades—the all-A student now averages C. If the boy's well-being rests on his grade status, he may have to re-evaluate himself and his aims. Incidentally, this is a case in which parents and school teachers may start throwing such epithets as lazy. This response by parents, usually not correct, doesn't help the student. It's a cruel fact of academic life that any grading system ranges from Excellent to Failure and that the placement in it is determined in the school or college administering it. If all the entering students had all A's in school (M.I.T. does *not* claim such a record!), there still would be a preponderance of C grades in the college with (happily) some A's and (unfortunately) some F's. Somehow or other, since it is the students themselves who determine what the average at M.I.T. will be, there will always be more average students here (M.I.T. average, that is) than any other variety.

There are all sorts of specific problems that can bedevil a fellow. And, from the lay point of view, the old idea of possession by devils isn't too far off the mark. Sometimes there is no apparent surface cause, no specific event to grapple with, no adjustment problem that one can see. And yet—things don't go right. We know of boys like this. We offer them the assistance of professional people who can probe deeply and get at the causes—causes no one in school, no Educational Counselor, no Admissions Officer, had any reason to suspect. But they are there. They interfere. They kick up surface manifestations that look like some of the other factors we have discussed. These can result in academic failure, too, if we're not skillful enough to at least hypothesize their existence and skillful enough and trusted enough to get the boy to seek professional help.

How Alumni Can Help

These paragraphs can leave a dreary idea of students. One gets to think of them as problems if one isn't careful to maintain perspective. After all, more than

(Concluded on page 44)



The old idea of possession by devils may have some merit.

When You Write a Report

Here are six principles to be remembered, and six ways to help the hurried reader

BY ROBERT R. RATHBONE

WHENEVER I hear engineers discuss the headaches of preparing a journal article or a technical report, I am reminded of a remark made several years ago by a friend of mine in industry: "There are some things that engineers hate more than having to write – ten years in Alcatraz or a case of beriberi!" I had never thought of the problem in just that way, yet I had to admit that many technical people do resign themselves at an early age to a sort of "peaceful coexistence" with the English language.

But the situation is not incurable. Engineers with whom I have worked have demonstrated that they can turn out clear, readable writing once they understand the basic principles and are given an opportunity to develop their technique.

My intent in this article is to describe the basic principles as specifically as I can in the space available. I am willing to risk another look at this much-discussed subject because I believe that too often it has been treated in such general terms as to be of little help.

The Important Man: the Reader

A technical report has a reason to exist only if the reader for whom it is intended will have some use for it. Consequently, all of the principles of sound reporting are based upon reader needs. Every decision a technical writer makes – whether on content, style, or format – must be justified on the grounds that the result will help the reader; each new reporting situation demands a fresh appraisal of the potential audience.

Although appraising the reader's needs for technical content is fairly straightforward (particularly if the report is being written by direct assignment), solving his needs relative to style and format is not. Most of these needs are psychological, and thus differ somewhat from individual to individual. Only those that are common to all readers of technical matter can be predicted, and effective ways to meet them prescribed. Fortunately for this analysis, the common needs outnumber the special needs.

Needs for a Clear Understanding

The first duty of a technical writer is to convey information clearly. To do so, he must meet these basic needs of the man at the receiving end:

1. ***The need for introductory material.*** All writers realize that it is important to make a good first impression on their readers. Yet many introductions are so sketchy that readers become hostile even before they begin to hear the evidence. The main trouble is an inadequate description of purpose. Many writers begin something like this: "The purpose of the investigation was to redesign component X to meet the following specifications . . ." What these writers fail to realize is that their readers immediately ask "Why?" They would do a lot better to begin this way: "System ABC is used for real-time applications at location Y. On October 1, the system did not detect target T. An investigation of the failure showed that component X had not responded to impulse I."

The point to remember is that all readers need at least the major points of briefing that the writer needed before he could begin the investigation. (Even the person who assigned the project wants to be sure the writer understands the problem thoroughly.)

2. ***The need for a picture of the whole.*** Just as the reader needs a picture of the whole problem in the introduction, so he needs similar guides throughout the presentation of evidence. In order for him to understand a new concept, a new machine, or a new method he must first have a clear idea of the essence, function, and purpose of the concept, machine, or method considered as a whole. He needs an over-all framework into which he can fit the parts as they are described. For example, if the reader is first given a general description of a chemical process, he will be ready to tackle the details of the many steps in the process. The verbal picture will help him in much the same way that the illustration on the box helps the man about to assemble a jigsaw puzzle.

3. ***The need for a sound structure.*** Once the reader has a picture of the whole, the parts should be presented to him in a pattern that is consistent with the nature of the subject matter. There are many ways of unfolding a story; *e.g.*, development based on time, classification, order of importance, cause and effect, or logical sequence. Usually, one method is better than another for a particular situation. It is up to the writer to find it, and until he gains experience, cut and try may be his only approach. For example, the construction of a device might be described by working from the inside to the outside, from the top to the bottom, or from the left to the right. If the general description does not immediately suggest which method to use, the writer should try several and compare. The one that was easiest to write should be the one easiest to read.

4. ***The need for proper levels of emphasis.*** All the details of a description will not be of equal importance.

(Continued on page 52)

Mr. Rathbone is Associate Professor of English at M.I.T. who has specialized in teaching technical writing.

Strong Chambers for Solid-Fuel Rockets

Engineers show what must be done if thin casings are to withstand tremendous stress

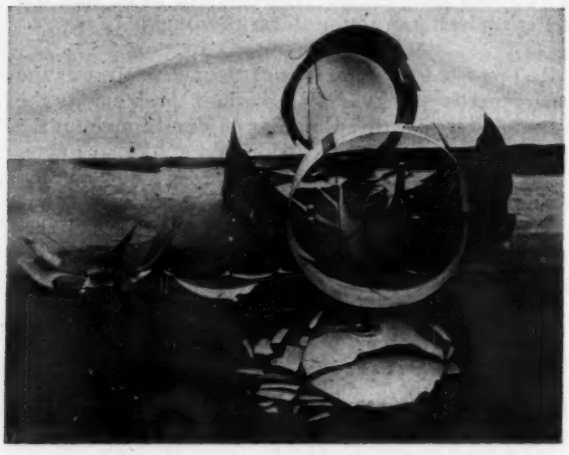
THE LATE Professor Robert H. Goddard and the Germans used liquid propellants in their rockets, and liquids have continued to be favored in big missiles despite the difficulties of handling them and the pumps and other appurtenances required. Solid fuels would be preferable in many instances, but they must be encased in very strong yet very light chambers. It has proven difficult in the past to design and fabricate such chambers.

Maurice E. Shank, '49, Associate Professor of Mechanical Engineering at M.I.T., recently participated in research work with Pratt & Whitney Aircraft engineers, which showed that:

¶ It is possible now to produce a solid-fuel rocket casing 6 feet long and 40 inches in diameter, with a wall only 7/100th of an inch thick, which can withstand a tangential stress of 240,000 pounds per square inch, but

¶ The cleanest, vacuum-melted steel available must be used, and handled with great care, because

¶ Even a hydrostatic test with water can cause electrolytic action that will so charge the metal with hydrogen that internal cracking will result, leading to subsequent fracture.



These are the remains of a full-scale casing that failed.

The experiments showed big casings like this are feasible.

Extreme care must be paid to the details of design and construction. In the successful casings, longitudinal welds were avoided by spinning the cylindrical section of the chamber from a solid, seamless ring forging, and bosses and reinforcements were integral with the dome-shaped heads. Learning these lessons was no small job.

In some respects, the situation reminded the researchers of problems encountered in the failure of welded ships during World War II, and the failure of carbon-plated steel structures before and after the war, but the difficulties were very much magnified in the rocket-chamber problem by the much higher stresses encountered. The stress in the chamber wall is equivalent to that in a one-inch-square rod holding a weight equivalent to that of 80 automobiles.

Exploratory work was begun by building some test chambers only 9.5 inches in diameter and 14 inches long. Then, after ascertaining that small chambers could be built, the investigators proceeded to make a big one – that failed unexpectedly at lower stresses than previously had been sustained.

The detective work undertaken then, to find out why it came apart during a hydrostatic test, was long and intricate but led the researchers to suspect that hydrogen in minute quantities was the culprit. A half dozen more sub-sized chambers and a couple of large ones were built and tested in order to be certain that hydrogen caused the trouble. Precisely how it gets into and initiates fractures in steel is not fully understood yet, but a lot was learned in these experiments about making big, sturdy chambers out of metal no thicker than 17 sheets of the paper in this magazine's cover.

Heretofore, it has been presumed that, since a missile only goes up once, its fuel chamber needed only to be made well enough to withstand one or a few severe tests. But now, says Professor Shank, "it has become apparent that a solid-fuel rocket chamber must be designed and constructed well enough to last through many stress applications, and for much longer periods of time than it will be stressed in service.

"If it cannot do this, it will not work at all.

"This has been realized in the aircraft propulsion field for many years and is the philosophy used in the manufacture of turbojet engines. If missile casings are to operate in a satisfactory manner, even higher standards of quality are in order."

The research was described in more detail in November and December, 1959, issues of *Metal Progress*.

Seeing Far Below the Sea

BY HAROLD E. EDGERTON

More photography in the oceans is needed . . . now dynamic, data-producing cameras are being developed

EACH time I look at a globe, I get excited again about the tremendous number of unknown things and facts that must be submerged under the oceans that cover more than half of the area of our earth. The best way to see what is going on would be to go down there in a submarine, like Captain Nemo, and have a look.

Auguste Piccard's bathyscaphes have been taking observers on just such trips. Captain Georges Houot of the French Navy in the FNRS III, for example, has made 70 dives in the Mediterranean, the Atlantic, and near Japan.* A team of American scientists, under the sponsorship of the Naval Research Laboratory, also made some 25 dives off the coast of Italy in 1958 in the *Trieste*. This bathyscaphe was obtained by the U.S. Navy and was reported recently to have dived more than seven miles in the Pacific, a world's record.

The French Navy is designing a new bathyscaphe capable of diving to the bottom of the deepest ocean. The first bathyscaphes were built to go to only about 15,000 or 20,000-foot depths, whereas the new French one will be capable of going to the ultimate depths known. There is no requirement for a deeper ship unless a new and greater ocean depth is found or a hole is dug.

Bathyscaphe Cameras

It was my privilege to design the flash photo equipment which was used on an early 13,285-foot dive of the FNRS III off Dakar. The research committee of the National Geographic Society had given me funds to design, build, and send this camera equipment to France for use in the pioneering exploits of this deep-diving submarine. Later, I spent a month in Toulon studying the photography problem. From this study, additional external cameras were designed, which are now in use on the vessel.

Electronic flash cameras controlled by pushbuttons at the observer's position are now standard equipment on both bathyscaphes. The photographs are one of the most valuable results of the dives, because they remind the observers of what they saw and enable others to see the actual scene at the bottom.

*This was clearly reported in the *National Geographic Magazine* in September, 1959, and January, 1960.

The dense zone of marine life *(at top of page)* was seen from one of the bathyscaphes.

The starfish clinging to the bottom at a depth of 6,300 feet were off the U.S. eastern coast.

The Gorgonian plant *(at the left)* was found in a photograph taken at a depth of 2,600 feet.

Professor Edgerton descended in a bathyscaphe last summer near Guadeloupe. Peter Gimbel took the picture on the preceding page then.

On the next page you see how data now are recorded on photos so that they cannot be lost.

Bathyscaphes, however, have operational difficulties, especially in the open ocean far from an operating harbor and base. Even in the relatively quiet Mediterranean, one must pick the good days to dive, and these are often far apart. It would be difficult to work far from a base at some of the great depths of the ocean.

More Photography Needed

Every time I go on a cruise, I am impressed by the small amount of actual time a research ship is "on station." Most of the time is spent going and coming. Possibly some day a large barge will be anchored at sea for a long time so that extensive experiments can be made, including photography, coring, and dredging, to yield a coherent picture of a particular area under study.

Our automatic cameras hanging on a wire or line can take a great many photos from the deck of practically any ship. We could be considered to be in competition with the bathyscaphes, but are really collaborating on the main problem of exploration. I personally favor a lot of preliminary activity with automatic cameras so a bathyscaphe observer will have the benefit of a photographic preview before he goes down. The effort required to lower a camera is small compared to that necessary for a bathyscaphe dive.

Automatically operating underwater cameras can follow several systems. One of the first methods of bottom photography was the "pogo stick" method. The camera and light are mounted on a vertical stick which has an electrical switch on the bottom. When this strikes the bottom, the photo is taken. Then the camera either is raised to the surface or pulled up a few feet and relowered for another flash. A sonar is sometimes used to give a "ping" when the photo is made. Otherwise the operator might not know at the surface that his camera had reached the bottom, because his steel lowering cable's weight becomes very pronounced at great depths. Professor Edward Thorndike of Queen's University uses the "pogo stick" method in the designs he makes for Professor Ewing of the Columbia Lamont Laboratory.

With sponsorship of the research committee of the National Geographic Society, I have had the opportunity to assist Commandant Jacques Y. Cousteau on his ship *Calypso* in his efforts to study the ocean by means of photography. Cruises in 1953, 1954, and 1955 were made in the Mediterranean; in 1956, in the Atlantic at the Romanche Trench; in 1958, off Monaco, and in 1959 off Puerto Rico, Guadeloupe, and Martinique. After each of these cruises I returned to M.I.T. with a list of the difficulties with the photo equipment and a list of the desired characteristics. There are still many limitations to the underwater photography equipment, but I feel that considerable improvement has been made. Before long, I hope, standardized underwater models will be in use in all the oceans, gathering and disseminating information to everyone.

One of these days a research ship will go to sea with photography as its high priority objective. Up to now, photography usually has had low priority on oceanographic expeditions. I know, in fact, of several expeditions that did not take cameras because of the added expense, which was microscopic compared to the cost of operating the ship and the expedition.

We seldom stop to think of the advantages of photographic recording since the technique is so commonplace. For example, how many bits of information can be stored on an ordinary 35-mm. negative? With only 20 lines per mm. resolution we can put down half a million facts on a single 1½-by-1 inch film. Few other media of recording information can match this.

Electronic Flash Lighting

My first recallable experience with underwater photography was helping Dr. Newton Harvey with a camera to photograph deep-sea fishes about 10 years ago. The new (at that time) electronic flash system of lighting offered a design which could take many photographs per lowering, as compared to the single-shot expendable flash bulb. Harvey's results were not up to his expectations. This conclusion still applies to most of the work today, although there is a bright spot once in a while. Tremendous numbers of photos are required to get one good one when the shooting is at random.

The electronic flash system has the following characteristics: (1) Many flashes can be obtained from a lamp. (2) Conversion of electrical energy to light is efficient. (3) The color of light resembles daylight. (4) Control of the quantity of light per flash is possible. (5) The instant of starting can be controlled accurately. Most of these advantages are utilized in underwater photography, especially the first.

My chief interest in photography has been in the development of electronic flash lighting equipment. Since Dr. Harvey's visit, I have made more than a dozen underwater cameras with flash attachments. In this work it has been necessary to develop special cameras with specifications that are particularly useful in casings that must withstand tremendous hydraulic pressures. I have had the co-operation of many people, especially that of Lloyd Hoadley of Woods Hole Oceanographic Institution on the casing designs, and Dave Owen on applications.

The "free floating" camera sometimes used is built to return to

the surface by its own buoyancy after reaching the bottom and taking a single photograph. If the camera is not found, one always wonders if it became stuck down there or just got lost.

Another design is the "continuously running" camera, which cycles at a known rate, thus exposing photos above the bottom and at different levels. One design, as used for several years, takes photos at 12-second intervals for about three hours, while 100 feet of film goes through the camera. There are 800 pictures in this length. New thin base "Cronar" film may enable the camera to expose double this normal number in one loading. A clock-driven switch also is incorporated in the design to introduce a delay of up to two hours, and thus prevent the camera from starting until it is near the bottom.

"Dynamic" Photography

It occurred to Cousteau and the author, after carefully examining thousands of midwater photos in and near the scattering layer, that a fast-moving camera is needed to surprise the mobile creatures that inhabit the depths. We think that a camera hanging from a stationary ship finds itself in a sphere of water devoid of animals except those that have no capability of flight, such as medusae, siphonophores, etc. Very rarely, if ever, have we obtained photos of shrimp, squids, etc., the animals which can flee from the flashes.

In August and September of 1958, while off Monaco, Cousteau and Alimat devised a paravane or drag on the bottom of a camera to hold it down while the ship was under way. A few tests were made which showed encouraging results, such as a hundred shrimp on a dozen concurrent photos. A depth-recording system consisting of a pressure gauge that was photographed on the film was necessary to show the actual depth at which the photographs were made. It is my firm conviction that this fast-moving camera with a data-recording section will prove to be a useful tool.

Cousteau also has devised an underwater sled to carry cameras on the bottom of the sea. Both still cameras and 16-mm. motion picture cameras have been used, with black-and-white and color film. A fast recharging 5 watt-second electronic flash was used with the motion picture camera at 20 flashes a second during the summer of 1958 off Nice and Monaco. The flashes were synchronized to occur when the camera shutter was open. The results were very exciting to us.

More motion pictures were made with an oil-cooled, 20-watt-second unit that operated at 24 frames per second during the cruise of the *Calypso* to America and back.

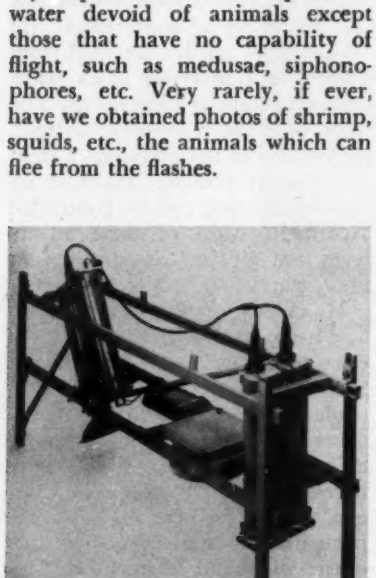
Data Cannot Be Lost

The latest model of camera, which is now being designed for a Woods Hole Oceanographic Institution project, will have a data-recording chamber in the camera to indicate on the film the depth (pressure), time (photo of a watch), and a data card with position, date, etc. This type of data becomes of greater importance as the number of films is increased, since it reduces the danger that films will be mislabeled or data lost. If the data are on the film, they will always be there.

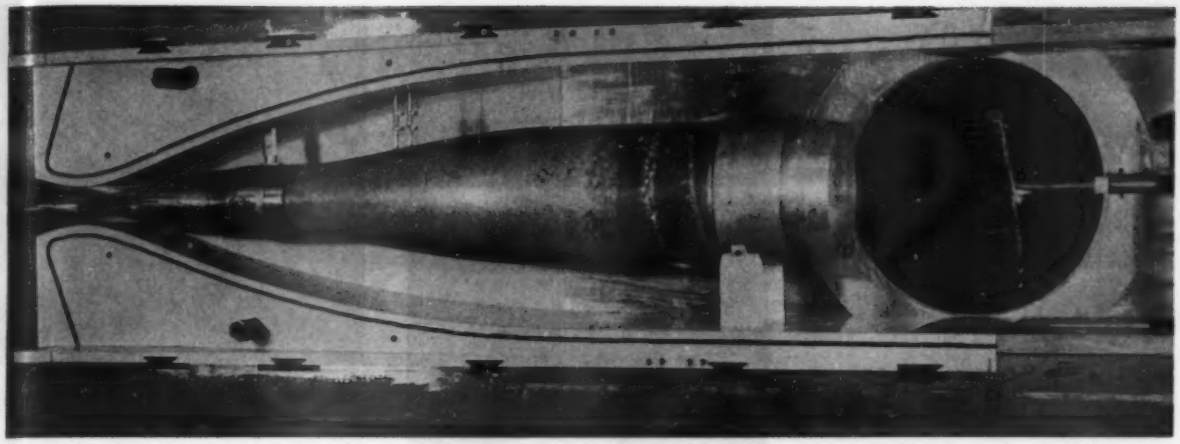
A sonar on the camera will indicate to the observer on the ship when a "sound scatterer" is in the axis of the camera. He then can push the button to take a photograph which will help him find out what is there. An effort is being made also to trip the camera automatically when a "subject" is in the field of the camera.

A lens especially designed by Professor Robert Hopkins of the Optics Department of the University of Rochester should give us additional information by producing a clearer wide-angle photograph. Distortions are experienced when a lens as used in air is used for underwater photography. The new lens is corrected for photography through the window and the water.

Libraries of photographs of the bottom of the oceans are needed. Several such collections have been started; for example, Dr. R. B. Hersey has several fine books with photos of the Blake Plateau which are available to all to study. I am sure that exchanges of photographs will be commonplace in the future among the world's research centers.



In frame *above*, strobe is at left, sonar pinger in center, and stereo cameras at right. Large picture shows a new camera removed from its case.



The new aluminum nozzle is inside of the wooden nozzle: 10,000 horsepower is used to push air through opening at left.

From Supersonic To Hypersonic

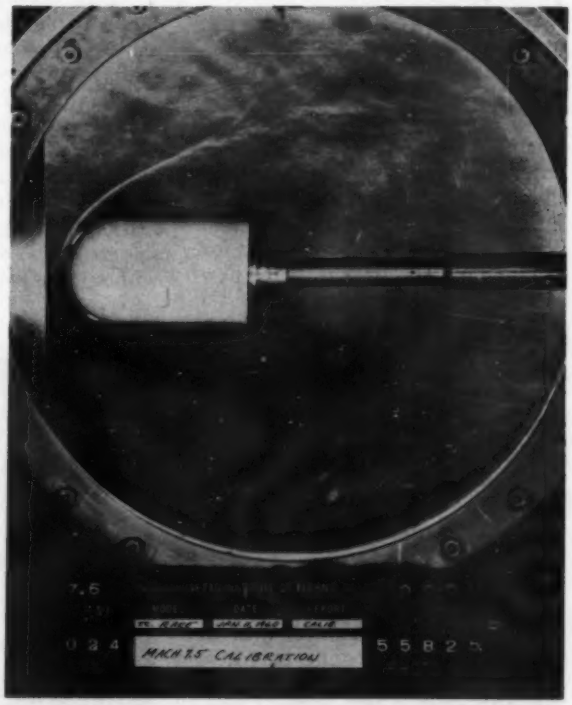
THE VELOCITIES attained in the Naval Supersonic Laboratory wind tunnel on Audrey Street, at the western end of the M.I.T. campus, have been about doubled. Briefly stated, this was done by placing a hypersonic tunnel inside of the original supersonic tunnel. Credit for this economical, technical advance is given by John R. Markham, '18, Professor of Aeronautical Engineering and Director of the Laboratory, to two of its senior scientists, Eugene S. Rubin, '45, and Jacques A. F. Hill, '47.

The necessary modifications cost only about $150,000. In other wind tunnels, where brute force is relied on, millions of dollars have been spent to attain the velocities that are now produceable in this tunnel. This is believed to be the first time that a wind tunnel in the United States has been modified in this way.

Although the laboratory currently is using air at only 100 pounds pressure and 1000 degrees F., velocities of more than Mach 7 (about 3,000 miles an hour at ground level) have been reached. Higher temperatures and pressures are expected to increase velocities to Mach 15 (more than 11,000 miles an hour), and electrical and magnetic means of ultimately attaining still higher velocities are being studied.

In all hypersonic wind tunnels, the air is heated to prevent it from turning to liquid as it passes through the nozzle. Like traffic speeding up after passing a bottleneck, the air goes faster and spreads out after it leaves the nozzle throat. Judicious design of the nozzle and control of the flows were necessary to reach higher velocities without increasing power requirements and heating problems.

The nozzle of the new hypersonic tunnel looks like a giant cigar holder. It is an aluminum casting (made by the Gorham Manufacturing Company of Providence) about five feet long and a foot in diameter, mounted inside of the 18 by 24-inch section of the supersonic tunnel. The hypersonic nozzle's interior is smooth and accurate to within thousandths of an inch.



Schlieren photo shows shock waves from model in tunnel.

A relatively small amount of high-pressure, heated air is fed to the hypersonic tunnel from an independent source. This air in the inner tunnel then responds to the lower pressure in the outer section and accelerates its own flow in an effort to fill this void. The outer supersonic stream continues and serves as an insulating blanket around this central hypersonic core.

The Naval Supersonic Laboratory is operated for the Navy by M.I.T.'s Department of Aeronautics and Astronautics. Many of the weapons now being adopted were tested in it, and it has become the principal experimental and research center for undergraduate and graduate students interested in problems of aerodynamics and aerodynamic heating.

A New Way To Make a Vacuum Tube

INEXPENSIVE, do-it-yourself vacuum tubes that can be used in laboratory experiments, and incidentally in simple radio sets, are being made this year by M.I.T. students as part of the program to modernize the teaching of high school physics.

Jerrold R. Zacharias, Professor of Physics and the guiding spirit of Educational Services Inc., which is producing new books and films for the high schools, has called the new method of making the tubes "a major breakthrough in vacuum technique," and expects it to have a revolutionary effect on physics instruction.

Modern physics is based largely on experiments requiring vacuum tubes, but making them by standard techniques requires both expensive equipment and highly skilled technicians.

This new method was worked out by J. H. Owen Harries, who heads a consulting and research firm in Bermuda, and has done extensive work on vacuum tubes, radar, and related problems. Pilot kits of parts are being tried out in colleges throughout the United States. The present kit sells for $50 and makes possible the construction of between 10 and 20 tubes. The choice of a triode as the first project was simply to test the technique; some 40 experiments are planned relating to a wide range of physical phenomena. An instruction manual will be cross-referenced to textbooks.

Applications of the technique in industry, and its possible uses in research work as well as in education are to be studied, too.—WILLIAM T. STRUBLE.

1 Glass tubing and commercially available glass stems which are already wired are joined with glass solder. The solder is fused at a temperature of 520 degrees C. in inexpensive, table-top ovens. These are made of sheet asbestos, fiberglass, Transite, and aluminum foil, and sit on asbestos-covered firebrick. The student above holds a soldered tube which was assembled without the help of a glass blower.

2 The next step is to seal off the tube at one end over a gas flame. Metal electrodes inside the tube have been clamped together, which eliminates the need for welding. A pair of pliers and a screwdriver replace the welding equipment. Chemical "getters" which will be used to achieve a high vacuum in the final stages of student tube-making already are inside the tube.

3 Is the tube vacuum-tight? This is a crucial step. If there is a leak the tube-makers may have to do some patching. For this test, the tube is hooked to a hose from a vacuum pump. A solution of acetone is put around the soldered joints by one student while another holds a tester coil. When there is a leak, the acetone shows in the interior of the tube as a blue-green glow. These trials of the technique were made in the M.I.T. sophomore physics laboratory under the supervision of John G. King, '50, Associate Professor of Physics.

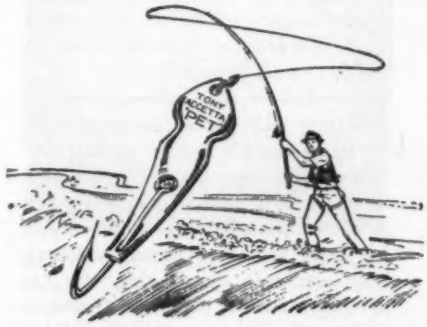
4 This is the final phase of obtaining a good vacuum. Barium, aluminum, and titanium are evaporated in the tube. Professor King (foreground) is shown increasing the current through heating wires already sealed into the tube, which gives off a glow as the chemicals evaporate. When this step is finished, the tube has a mirror-like coating on the inside of the glass envelope. The equipment and skills required when this simplified process of tube-making is followed are within reach of most schools and students.

BUSINESS IN MOTION

To our Colleagues in American Business . . .

Wham! And the fisherman hooks another record-breaker on the lure you see below. Just as that smart angler knew how to successfully fish that "Pet" Spoon bait so did the maker who designed and perfected it know exactly where to go in search of the brass from which to make that lure.

In order to produce the finest quality bait at a competitive price, he knew that he required a metal that could be easily stamped and formed, and of such quality and uniformity of grain structure that only the minimum of finishing would be required prior to the chromium plating of the lure.



Past experience had proved to this artificial bait manufacturer that, of the various commercial metals available, brass was the metal to use for this lure. For brass is easily stamped and formed . . . has just the right "heft" for casting, does not rust and it takes chromium plating as a fish takes to water. But when it came to selecting the exact type of brass that would best fit his exacting requirements, he called on Revere.

The result was a Revere Brass with special grain size and finish, and just the right ductility so that even after stamping and forming only a minimum of work is required prior to chromium plating.

Said the manufacturer, "Without a doubt, the fine quality of Revere Brass has contributed immeasurably to the quality of our baits, at the same time saving us money on forming and finishing cost. In fact, it is the quality of the material, plus design and workmanship that has made it possible for us to be awarded the Medal of Honor by the Sportsman's Club of America for the superiority of design and fish-getting ability of our baits, as well as the National Sportsman's Research Award, which is a real tribute to the design, workmanship and effectiveness of our lures."

The experience of this manufacturer, once more illustrates how, only by working closely with your supplier are you able to realize the highest return per dollar spent. That, too, is why it may very well pay you to let Revere help you "fit the metal to the job." Others have profited by this service, why don't you take advantage of it?

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Engineering Education

(*Concluded from page 29*)

facilities, and most important, in faculty for engineering schools. Each of these problems is really serious. They can be solved only if as a nation we place a sufficiently high value on education to generate the major effort, and the will, to solve them. There is a certain time element, however, that makes the faculty problem especially serious. Given a sufficient sense of urgency, money and facilities can be provided in a relatively short time. Faculty, however, require time for growth and development, and hence needs must be anticipated over a long time.

The faculty recruitment problem in engineering colleges is augmented by the intrinsic nature of engineering and of its appeal to young people. One goes into engineering because he likes to build things, to see structures, machines, processes, and products developed and produced by utilizing skillful applications of science. The natural expectation for the new bachelor of science in engineering is therefore to seek a job where these things are being done, primarily in industry. Even graduate work often is not seriously considered, especially by a senior in a school that stresses primarily undergraduate work, and whose bachelor product tends to follow a pattern of employment in industry. The possibility of a career in engineering teaching rarely enters the mind of the engineering senior unless through some special opportunity he has assisted a professor in his teaching. Most of our present teachers entered teaching by the back door when called upon to do some teaching as a means of earning money to continue in graduate school. Thus it was almost by accident that they discovered the attractions of the life and activities of a teacher.

The Committee on the Development of Engineering Faculties of the American Society of Engineering Education stresses that the really critical element in solving our engineering faculty problem is the choice made by the well-qualified engineering senior between immediate employment and residential graduate work. Statistically the probability that an engineering graduate will enter teaching once he has accepted industrial employment following the baccalaureate is very small indeed. If he chooses residential graduate study, however, his later choice between industry and academic life is aided by his graduate school experience, and is still made without prejudice, since graduate work enhances his value for either field. Once the faculty in the graduate school gets the opportunity to see and work with the well-qualified student, the way is open to explore, through discussions and actual experience, his potential and interests for academic work as well as for industry.[2]

Central to the solution of this faculty problem is an adequate salary structure. Too many faculty salaries today are not, for example, adequate to give faculty children as good educational opportunities as their parents enjoyed. We have reason to believe, however, that the *better* academic salary scales available today are not entirely unsuccessful in attracting and holding some good people, and that the ultimate potential for recruits to teaching among today's engineering seniors has been only modestly explored. We get encouraging reports that many students can be interested in the intangible attractions of a vigorous scholarly life in a university environment by friendly chats with a respected professor. Not all of our young people today appear to be the crass materialists that some would have us believe. They appear quite competent, given honest and articulate counsel, to place dollars and other values in valid personal perspective.

Our Vital Need

I emphasize faculty because faculty are the *sine qua non* of an engineering school, as of any element of a university. Students will face the demands of tomorrow's or any, new technology without a qualm if they are guided and inspired by faculty who themselves understand new fields. The student doesn't recognize a new field as being difficult unless so taught by his professor. If the professor sees a new field as something that offers excitement, the opportunity for absorbing new work, and for helping to solve some of the current problems, and if the professor has real insight and understanding in these matters, his students will share these outlooks and attitudes, They will master the necessary disciplines with surprising unawareness that some years ago these areas would have been regarded as frightfully advanced and difficult.

Our vital need, therefore, for meeting the problems that face us in engineering in the future is for adequate numbers of really first-rate faculty in our engineering schools. If we can attract such faculty and back them with adequate support, both material and moral, we need have no fear but that engineering programs will evolve in a continuing process that is responsive to the ever-growing demands of our new technologies.

M.I.T. on TV

A SERIES of one-hour television programs in recognition of the centennial of M.I.T. will be presented on the CBS Television Network during the 1960-1961 season. Each program will feature a currently important area of science.

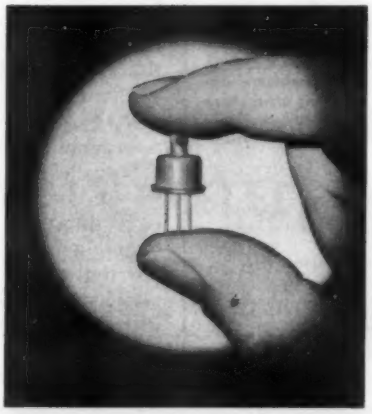
The American Machine & Foundry Company will sponsor these "Tomorrow" programs and they are to be presented in prime evening time.

In announcing the series, President Julius A. Stratton, '23, of M.I.T. said: "We at M.I.T. welcome this opportunity to join forces with the CBS Television Network in bringing to the attention of the American public both the fascinating and significant advances currently being made along our scientific frontier and some indication of how these advances may affect the lives of all people."

[2]The Committee on the Development of Engineering Faculties last year published a little booklet, *Teaching Tomorrow's Engineers*, which is achieving rather wide circulation. It tries to help the engineering senior think about whether teaching might possibly be of interest to him, and whether his aptitudes and interests are such that he should in any case seriously consider graduate work, thus keeping the way open to a possible teaching career. It is available on request, without charge, from W. Leighton Collins, Secretary, A.S.E.E., University of Illinois, Urbana, Ill.

Good Telephone Service and Good Telephone Earnings Go Hand in Hand

There is no way to have one without the other



NEW AND BETTER SERVICES for telephone users will come from the Bell Telephone Laboratories invention of the Transistor, a major scientific breakthrough. This mighty mite of electronics, which can amplify electric signals up to 100,000 times, will play a big part in push-button telephony, for example. The Transistor has been made possible by basic physical research that can only be undertaken by a progressive business with good earnings over the long pull.

The function of the Bell System is to serve you and serve you well.

It works two ways.

We must serve well to prosper. And just as surely we must prosper to serve you well.

Progress does not just happen. It has to be encouraged and made worth while. And it costs money; in the telephone business a whole lot of money.

Sheer prudence would bring a hesitancy to go full steam ahead if there are too many restrictions on profits. Or if the rewards of efficiency, good research, good management and downright hard work are sliced away as soon as earned.

In the telephone business there is special need for a sustained level of adequate profits. For the telephone business, more than almost any other, is a long-term business. Always we must keep building ahead to meet the needs of tomorrow.

These needs are growing every day. Just the gain in population alone gives some idea of their size.

By 1970—just ten years away—there will be 40,000,000 more people in the United States. More and more communication services will be required by people, industry and defense.

So when we emphasize the need for satisfactory earnings on a continuing basis, it is for a very practical and useful purpose. It helps us, of course. But in a very real sense it helps you.

Only with adequate profits can we run the business most efficiently and take advantage of long-range economies.

Only with adequate profits can we finance and put in operation the latest advances in telephone science.

All this not only improves the service but helps to hold down the cost of providing it.

The result over the long run is bound to be better service for you at a lower price than you would otherwise have to pay.

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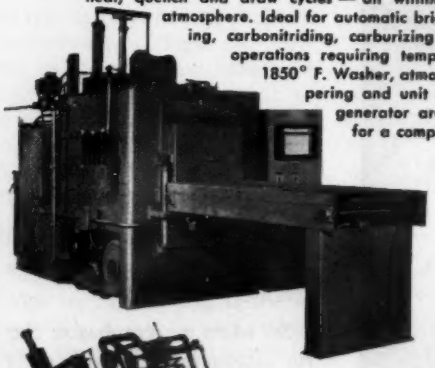

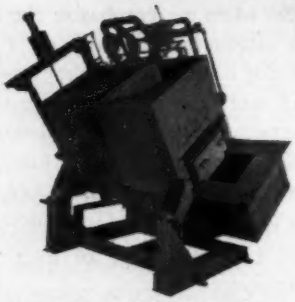

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Why Do Good Men Fail

(Concluded from page 32)

70 per cent of our entering students complete their programs on time and only 7 or 8 per cent fail during the first year. Of these, a significant portion of those who withdraw for other work are convinced that M.I.T. was a happy and valuable experience. In the balance, too, are the freshmen who carry a full academic load (sometimes an overload), do well in all their subjects, and take an active part in campus life.

There is no doubt that many students who are ultimately successful have encountered some of these problems on the way. This is one reason why we cannot abandon our failing students with a simple explanation such as "poor preparation" or "laziness." Nor do I think that anyone would agree that we should shelter all of our children to the extent that none of them ever would have to encounter these problems. Education for creative living and the retention of the status of baby from cradle to grave are incompatible concepts. It is not at all clear to me that we should avoid the risks inherent in having students who might fail – even if we could tell which are which. We would, in the present state of the art, miss some real stars, too.

One clear impression gained from this work is that we are not skillful enough to tell which students will have difficulty. Most frequently, we spot the wrong ones when we try to do this before the student arrives. (By that time, in addition to the admissions data, we also have a specially solicited letter from the parents introducing the boy to us.) But it is possible to find an admissions folder of a boy on the Dean's List which reads just like that of a boy in difficulty. There are simply some things about any person that are different after he has lived another year, especially if there has been a big change in his physical, mental, and spiritual environment.

As Educational Counselors and Admissions Officers, we should strive to be sure that the student knows as clearly as can be known what he is planning to do. This is guidance. We should present him with a factual picture of college, of M.I.T., and of professional life. We should use every means at our disposal to see that he knows the meaning of the words he uses – science, engineering, humanities, that he has opportunities to test his aptitudes and skills rigorously, that his motivation is relatively strong, and that he realizes that, however we like to pretend, we adults do share our burdens with those who want to help us.

If we can do these things, recognizing that however well we do we are capable only of increasing the probability of success toward the maximum, but never to it, we can make a real contribution to the young people who decide to come to M.I.T.

Music at M.I.T. in March

CONCERTS scheduled in Kresge Auditorium include: March 8, 8:30 P.M., André Marchal; March 12, 8:30 P.M., All Tech Sing; March 13, 3 P.M., Juilliard Quartet; March 18, 8:30 P.M., M.I.T. and Pembroke College Glee Clubs; and March 20, 3 P.M., M.I.T. Choral Society.

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to Nuclear Engineers, Physicists, Metallurgists

Openings are immediately available for Nuclear Engineers, Physicists and Metallurgists interested in applied research, development or design of novel reactors at The Knolls Atomic Power Laboratory. The broad aim of these endeavors is to achieve a new regime of simplification in reactor technology.

Address your inquiry to Mr. A. J. Scipione, Dept. AL.

Masters Degree Program. KAPL is now considering recent graduates in ME, Met, Met E, ChE, Physics, EE, Nuclear E. and Marine E. for its masters degree program in nuclear engineering in conjunction with Rensselaer Polytechnic Institute. Applicants should have strong interest in nuclear field and must have graduated in upper 10% of their class. Selection of candidates will be completed by April 1; classes begin September, 1960. Write for further details.

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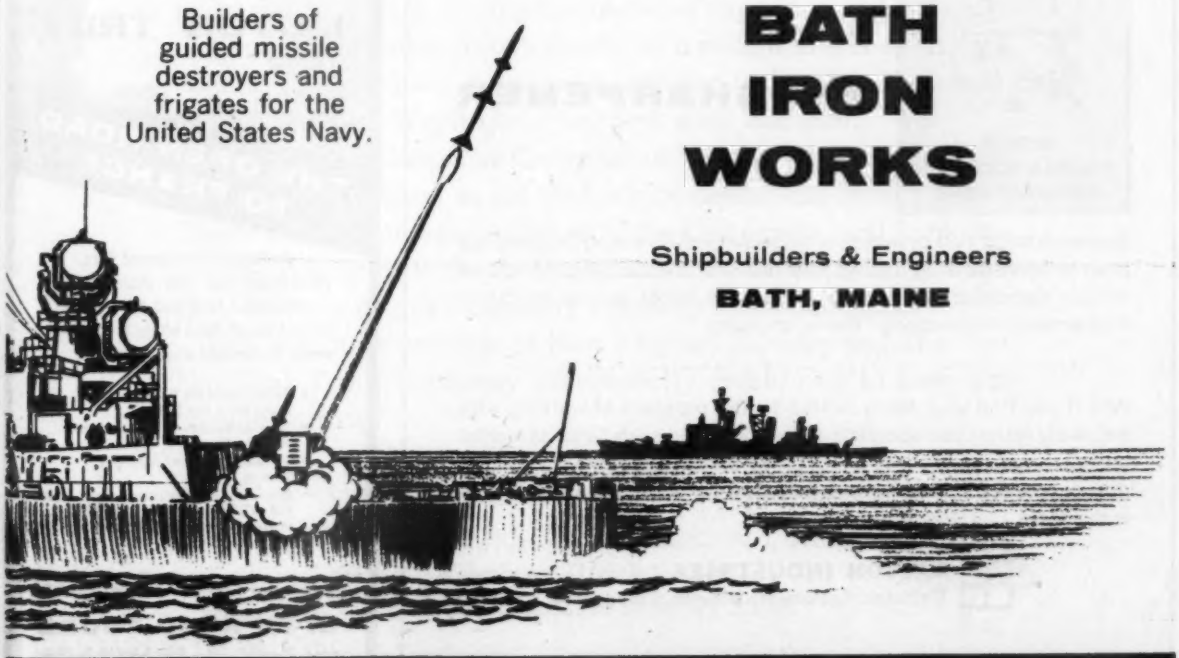


Individuals Noteworthy

(Continued from page 12)

New Posts

NAMED in the news recently were the Alumni and members of the Faculty whose elections, promotions, and appointments are recorded below:

Raymond H. Blanchard, '17, as President, Associated Industries of Massachusetts . . . *John J. Healy, Jr., '21,* as Vice-president, American Institute of Chemical Engineers . . . *Dana C. Huntington, '21,* as a Director, Framingham National Bank . . . *Henri P. Junod, '21,* as President, American Coal Sales Association;

Alfred E. Perlman, '23, as a Director, Alleghany Corporation . . . *Paul J. Cardinal, '24,* as Treasurer, National Vitamin Foundation, Inc. . . . *George J. Taylor, '26,* as Vice-president in charge of Research, Development and Marketing, Day-Brite Lighting, Inc., St. Louis;

William Wraith, Jr., '26, and *Thomas K. Graham, '35,* respectively, as Assistant Vice-president and as Metallurgical Manager, Anaconda Company . . . *Clarence L. A. Wynd, '27,* as General Manager, Kodak Park Works, Eastman Kodak Company;

Walter F. Burke, '29, and *Ben G. Bromberg, '47,* as Vice-presidents, McDonnell Aircraft Corporation, St. Louis . . . *Clarence M. Chase, Jr., '32,* as Assistant to the Treasurer, Union Carbide Corporation . . . *William G. Ball, Jr., '34,* as Assistant Director of Public Relations, Ethyl Corporation;

William F. Bode, '36, as Vice-president and General Manager, Selig Company, Atlanta, Ga. . . . *Charles R. Holman, '36,* as Plant Manager, Pittsburgh Plate Glass Company, Springdale, Pa. . . . *James McCormack, '37,* as a Director, State Street Bank and Trust Company, Boston;

James D. McLean, '37, as President, Stromberg-Carlson Division, General Dynamics Corporation . . . *Thacher H. Fisk, '39,* as General Counsel, Kendall Company . . . *James E. Seebold, '39,* as Co-ordinator, Process and Engineering Development, Standard Oil Company of Indiana;

Thomas F. Malone, '46, and *James M. Austin, '41,* respectively as President and Secretary, American Meteorological Society . . . *Newman M. Marsilius, Jr., '42,* as President, Chamber of Commerce, Bridgeport, Conn.;

Charles A. Hathaway, '43, as Assistant General Manager, Air Impeller Division, Torrington Manufacturing Company, Torrington, Conn. . . . *Robert V. Bartz, '44,* as Executive Director, Associated Rocky Mountain Universities, Inc. . . . *Edmond G. Dyett, Jr., '47,* as President, National Noise Abatement Council;

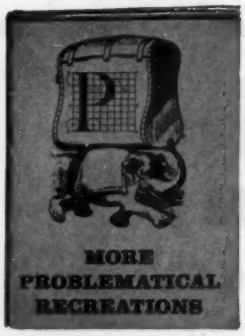
Peter P. Poulos, '47, as Scientific Director, Heart Institute of United Hospitals, Newark . . . *William B. S. Leong, '48,* as Planning Director, Haverhill, Mass. . . . *John J. Glover, '49,* as Chairman, Division of Chemical Marketing and Economics, American Chemical Society.

Honors

MEDALISTS and recent recipients of other awards include:

Augustus B. Kinzel, '21, the James Douglas Gold Medal, by the American Institute of Mining, Met-

(Concluded on page 48)



WIT-SHARPENER

Response to our first collection of these delightfully vexing enigmas has been so heart-warming that we have decided to issue a second volume for your delectation. Write to our Dr. William Jacobi, and ask for "More Problematical Recreations." Gratis, of course.

And if you find your fancy tickled by the prospect of working with nationally recognized scientists and engineers in such fields as inertial guidance, radar, tactical data processing systems, airborne digital computers, or space research investigations, you will want to communicate with our Mr. C. T. Petrie.

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When Lombard Governor Corporation of Ashland started banking with The New England Trust Company in 1946, it manufactured a narrow line of products. Though the Corporation was successful, the late Henry E. Warren, owner and President, felt that a broader base of operations was desirable.

Between 1946 and 1956, Mr. Warren successfully expanded and diversified the Company's products to include the manufacture of power chain saws and plastic molding machines, in addition to hydraulic governors. During this period of expansion, the net worth of the Company grew from a quarter of a million to over one million dollars. The Company continues to prosper under the able leadership of Mr. Max Woythaler, President since late 1957.

As Lombard Governor Corporation's business increased and changed in character, so did its banking needs. The New England Trust Company, in conjunction with the Company's local bank, has continued to provide the credit needed in the development, production, and sale of this expanding Company's new products.

This is another example of New England industry and The New England Trust Company successfully combining to keep our economy strong.

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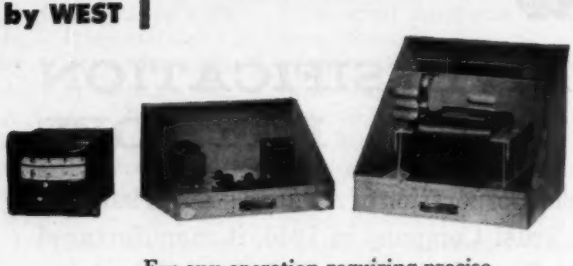

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The most compact programming system available includes Model JSBG (left) for any operation involving a time-temperature cycle. Its simply cut cams integrate and control time with temperature.

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Individuals Noteworthy

(Concluded from page 46)

allurgical, and Petroleum Engineers . . . *Norman L. Weiss, '23,* the Robert H. Richards Award, by the American Institute of Mining, Metallurgical, and Petroleum Engineers;

James R. Killian, Jr., '26, the Gold Medal of the International Benjamin Franklin Society . . . *Elias J. Corey, Jr., '48,* the Award in Pure Chemistry for 1960, by the American Chemical Society . . . *Benjamin Lax, '49,* the Oliver E. Buckley Solid-State Physics Prize for 1960, by the American Institute of Physics.

Alumni Day Committees

THE 1960 M.I.T. Alumni Day Committees will be headed by Philip H. Peters, '37, as Chairman; Albert O. Wilson, Jr., '38, as Deputy Chairman; and Wolcott A. Hokanson, Staff, Registration; Robert C. Dean, '26, Symposium; and John L. Danforth, '40, Luncheon. Mr. Wilson will also head the Committee on the Banquet and Evening Entertainment. Subcommittee members will be:

Registration — G. Edward Nealand, '32, and Robert E. Hewes, '43.

Symposium — Gregory Smith, '30, Jay Zeamer, Jr., '40, Gerald V. Quinnan, '45, Arthur L. Bryant, '44, and Irwin W. Sizer, Faculty.

Luncheon — William H. Carlisle, Jr., '28, Vincent T. Estabrook, '36, David P. Flood, '45, Mrs. Nathaniel McL. Sage, '13, Philip A. Stoddard, '40, and Aaron M. White, '39.

Banquet and Evening Entertainment — Harold Bugbee, '20, Cason Rucker, '35, Edward R. Marden, '41, Edwin H. Tebbetts, '46, Arnold S. Judson, '47, Miles P. Cowen, Staff, William Morrison, Staff, Lloyd deW. Brace, Jr., '56, and Mrs. John W. Sheetz, 3d.

Local Activities

A COMMITTEE headed by Dr. Egon E. Kattwinkel, '23, has been authorized by the Alumni Council to review and recommend long-range plans for the Association's activities, especially in the area in and around Cambridge and Boston.

Its members are John A. Lunn, '17, Hugh S. Ferguson, '23, Carroll L. Wilson, '32, Clarence R. Westaway, '33, and James G. Kelso, Executive Assistant to the President.

Feedback

(Continued from page 3)

the fact that the simplest mathematical models for a suspension bridge and a steel arch bridge differ only by a change of algebraic sign in one parameter which converts tensions to compressions. Descartes owed much to Rudolff (1525), Viete (1591) and other predecessors. Thus the Cartesian notation and point of view represents the culmination of a century of effort. This notation has proved of great technical convenience during three centuries of applications, and should not lightly be thrust aside, even as a temporary step in mathematical education.

The Madison Project group really goes overboard on the do-it-yourself idea, or in traditional terms, the Socratic method. This method is quite successful in college students' bull sessions, particularly if they are discussing a question like Free Will versus Determinism, for which answers and conclusions today differ little from those described by Plato more than 2300 years ago. But subjects like mathematics, physics, and engineering are cumulative in the sense that they do move forward from generation to generation. And it is too optimistic to believe that even a bright high school group, led by a well-informed and skillful teacher who can control the thought trend without seeming to, can construct a system and notation for algebra that took a genius like Descartes, profiting by the accumulating results of a long sequence of earlier mathematicians, to achieve.

In a recent statement from the M.I.T. Admissions Office about the plane geometry requirement, stress is put on the possibility of omitting some of the theorems from the traditional course, so as to make room for some topics from analytic geometry and solid geometry. This type of modernization has the complete sympathy of the writer if the following limitations are understood: To be as effective as the traditional course, sufficiently lengthy chains of theorems, each deduced from preceding theorems or assumptions, to give the student an idea of the structure of a mathematical science must be retained. And the majority of the theorems which are proved should be presented in the traditional complete form with steps and reasons. To be sure, there are a few lacunae in the reasoning of Euclid (c. 300 B.C.), such as that found by Pasch (1890) and rectified in the formulations of Hilbert (1901) and Veblen (1917). But to use these as an argument for completely ignoring Euclid's type of presentation is a serious mistake. The fact is that even our youngest professional scientists of today have been greatly affected by having, as their ideal of a logically presented argument, the Euclidean-type proofs of their high school geometry textbooks.

The writer thinks it even optimistic to expect reasonable efficiency in teaching graduate physics students the theory of functions by the raise-it-by-your-own-bootstraps method, since it took, among others, Cauchy, Weierstrass, Goursat, and 150 years, for this field to reach its present

(Concluded on page 50)

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Feedback

(*Concluded from page 49*)

development. But Professor Davis has many equally optimistic colleagues, who try to educe Boyle's law from General Education students at Harvard, and Newton's laws of motion from physics students at M.I.T. largely by the students' own ratiocination.

Throughout their study of mathematics in high school, many pupils maintain the illusion that in mathematics the next step is inevitable—perhaps not quite obvious, but something that they could have figured out for themselves with the same mental effort needed to solve a problem set by an expert in the game of contract bridge. But as the more advanced fields of mathematics are studied, sooner or later, results and proofs of a much more complicated nature are encountered. These are so involved that no one, starting from scratch, would be likely to develop them for himself in a single lifetime. Even their originators obtained them only by pushing a little beyond the results of their predecessors. To cite just one result which few mature mathematicians would care to attempt as an original exercise, I mention the following fact which was proved in connection with Kummer's investigations of Fermat's last theorem: If p is a prime (i.e., having no divisors other than itself and unity) positive integer less than 2,000, and $2^p - 2$ is exactly divisible by p^2, then $p = 1{,}093$.

I shall not attempt to guess the time that would be required for a group of M.I.T. freshmen who have elected to study Elementary Number Theory to deduce by themselves one part of the result just stated, namely that if $p = 1{,}093$, then $2^p - 2$ is exactly divisible by p^2. But I can state that by using known methods of this field, I have often succeeded in presenting a proof of this to such a group of freshmen in 15 minutes.

The fact that $2^p - 2$ is exactly divisible by the first power of p for *every* prime p and its proof might be re-created by a class if given a little guidance. For example, if the class were asked a question, which Euler asked himself in 1736, about the form of the expansion of $2^p = (1 + 1)^p$ by the binomial theorem.

The do-it-yourself idea has been used in fields other than mathematics. For example, in some beginning painting classes the pupils do no copying or studying of older work in order to avoid warping their primitive inspirations. Of course, they also learn nothing of perspective. Not surprising, since few artists appreciated it before 1500 and the works of art by that versatile architect, scientist, and engineer, Leonardo da Vinci.

It is noteworthy that parents who develop enormous enthusiasm about their children's ability to evolve mathematics by themselves, have less faith in this approach elsewhere. Such parents would not dream of tolerating the hiring of a football coach with no experience who was unwilling to study the strategy of his colleagues and predecessors and teach it to the team. Perhaps in this field they have a more immediate pressure for efficiency, the desire to win. This same failure of do-it-yourself is also evident to any serious devotee of the game of chess who has seen a number of mediocre players who remain wood-pushers largely because they are unwilling to profit by some study of master play.

Perhaps some of the writer's reservations about the novelty of educational experiments are due to his observations at M.I.T., where tolerance of the status quo is as rare as a calm ocean. A favorite remark of Professor Douglass' is that such experiments have a cycle of 10 or 12 years. Like the writer, he has now seen three full cycles.

May all teachers make full use of the dynamism generated in both students and teachers by the idea of participating in educational experiment and research. But let them remember that if you want a class to appreciate the language of a play by Shakespeare, it is more efficient to have them consult a library copy than to set 12 monkeys before typewriters, and wait until by chance the play is again written.

Department of Mathematics
M.I.T., Cambridge, Mass.

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When You Write a Report

(Continued from page 33)

Yet sometimes the reader inadvertently attaches undue weight to a statement simply because the writer was not careful in separating and labeling his primary and secondary evidence. Then, too, readers feel that the amount of space allotted to a topic has a direct connection with the importance of that topic. If a certain piece of secondary information contains so many details or qualifications as to require a large amount of text, the writer should summarize the information, relegating the details to an appendix. Descriptions of procedure often fall into this category, as do development of equations and discussions of test equipment.

Improper emphasis can, and frequently does, occur at the sentence level. Many of us think of grammar as a restriction rather than an aid to writing. So we fail to utilize an important tool that will assure a proper structure for our thought. The rule is: *Put main ideas in main (independent) grammatical constructions; secondary ideas, in secondary (dependent) grammatical constructions.* The writer who says, "The solution is best determined by field test and is 50 volts," has assigned equal weight to two ideas. Surely the statement of the value being 50 volts is the more significant, and a simple revision would so indicate: "The solution, best determined by field test, is 50 volts."

5. ***The need for separation of fact and opinion.*** Naturally, every reader wishes to be able to distinguish between fact and opinion and between the views of the author and those of others. Thus every statement of opinion should be labeled and the person responsible for each identified. Plagiarism is not the issue. But since the pronoun "I" has been outlawed from many areas of technical writing, the author's personal views are frequently mistaken for those of accepted authorities in the field. Such common expressions as "It is believed that . . ." and "It is concluded that . . ." are cases in point. If personal opinion is not in order, then any way of expressing it is wrong. However, if the reader wants the author's views, then "I believe" is better than "The author believes," "It is the author's belief that," "It is believed that," or "We believe." For the formal company report, though, the author must say "The Engineering Department recommends," "BW&N believes," etc.

6. ***The need for precise, straightforward language.*** For technical reports, the best style is one that does its work quietly in the background without calling attention to itself. The reader is after information, not an emotional experience. He asks for clarity and efficiency of expression, not impressive language. The major faults are illustrated below:

Fuzzy words — Plates of *appreciable* thickness. . . . A *relatively* high temperature. . . . A *small number* of failures.

Euphemisms — "A rapid structural failure occurred." . . . "Six tests were run and the firing curves were very smooth for all except the first, third, fourth, and sixth." (Both are from the Aerojet-General Style Manual.)

Overformal words — Conditions should *ameliorate* as

soon as the maintenance crews are *inculcated* in the theory of operation.

Jargon and coined words — The system can be introduced with *effectivity* within six months. . . . All the components are *ruggedized*.

Clichés — Last but not least, we intend, in the long run, to explore every avenue which might lead us to a solution along this line.

Needs for a Rapid Understanding

Today every reader is in a hurry. He has so much to read that he has to skim nearly everything if he is to get through the daily pile of papers on his desk. He also has to read discontinuously, since the pressures of his job seldom permit him to read a report from cover to cover in one sitting.

From a practical viewpoint, the writer must cater to these needs. He must build ease of reading into his style and format. Actually the job is not so difficult as it is time-consuming. But this is justifiable, since the object is to cut down on reading time.

The following are suggestions for tailoring the prose and mechanics to the rapid reader:

1. *Use descriptive headings and subheadings freely.* They act as signposts, group related material, and show the interrelation of the parts and their contribution to the whole. Newspapers use headings, why not reports?

2. *Put the topic sentence at the beginning of a paragraph.* This gives the reader a choice. He can either read the details on the topic or skip to the next paragraph.

3. *Use a simple structure for a complex idea.* Whenever the thought is involved or otherwise difficult to describe, the grammatical structure should be simple. Three short sentences are easier to read in this case than one long one; a paragraph of technical description more than a page long usually has to be reread.

4. *Relegate secondary material to an appendix.* Main ideas will stand out if not buried by incidentals, however pertinent. Data sheets are the worst offenders.

5. *Make full use of visual aids.* Curves and tables that summarize detailed results are invaluable. Most readers have trained themselves to extract the information they need, at a glance. But always supply captions and legends and refer to the figure at that point in the text where the reader needs the information.

6. *Provide white space around the text.* Readers of technical reports quickly reach a point of fatigue. Margins, indentations, space between headings, and short paragraphs relieve the eye — and the mind.

To summarize, the purpose of a technical report is to convey information from one mind to another. If the information misses its mark, both the writer and the reader have wasted precious time. No set of rules can be compiled that will cover ways to meet all the needs of a reader. But perhaps the dozen ideas presented here will help.

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Books

WAVES AND THE EAR, by William A. Van Bergeijk, John R. Pierce, '52, and Edward E. David, Jr., '47; Doubleday and Co., Inc. (95 cents). *Reviewed by Paul Cohen, '35.*

THIS explanation of what is currently known about the hearing of animals and humans has been prepared by three investigators at the Bell Telephone Laboratories as one of the Science Study Series. Several other volumes in this fresh approach to the teaching of physics have been reviewed in these columns previously. These books are directed primarily to high school students, but this does not prevent them from being challenging material to any interested layman.

The present work is exceptionally comprehensive for an introductory text, and bears on every page the authoritative imprint of authors who are immersed at firsthand in the subject they are explaining. Indications that they are themselves working at the frontiers of the field are the frequent references to the problems yet unsolved and to the areas of debate. Reference to the mechanism of good transmission in air, to the techniques of measurement, and to the definition of terms is held to a minimum. Most of the book deals with the mechanism of animal and human hearing, and what the nerves and brain may do with the received signal. "What Do We Hear?" is one chapter heading. "Nerves and the Brain" is another.

A reviewer is like someone looking into a mirror. He tends to see largest in every book those topics which reflect his own interests. In this case, the reviewer, who is interested in controls, computers, and data processing, is impressed by the complexity of the biological transmission system between ear and brain. The auditory nerve, as it leaves the cochlea, contains some 30,000 individual neurons (in man). This nerve branches off into at least 30 times as many extensions as it enters the cortex. Exhibiting a property found in many other brain functions, the auditory response can continue with little apparent deterioration in spite of massive damage to the nerves and brain structure. Nearly half the auditory nerve can be cut before impairment of single tonal response is detected. The authors quote J. C. R. Licklider, formerly of M.I.T., who states that one of the basic facts of neurophysiology is that the nervous system works in spite of a considerable amount of misarrangement — "the principle of sloppy workmanship," he calls it.

In spite of the impressive structure devoted to hearing in the human brain, we do not necessarily do as well as some other animals. A bat can be taught to distinguish between echoes from a cross and a circle of the same surface area. Griffen's work with bats, and Navy-supported work with porpoises, give many other

(Concluded on page 58)

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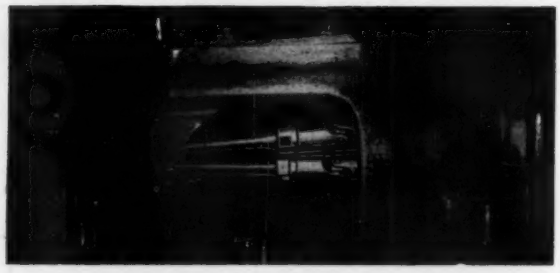

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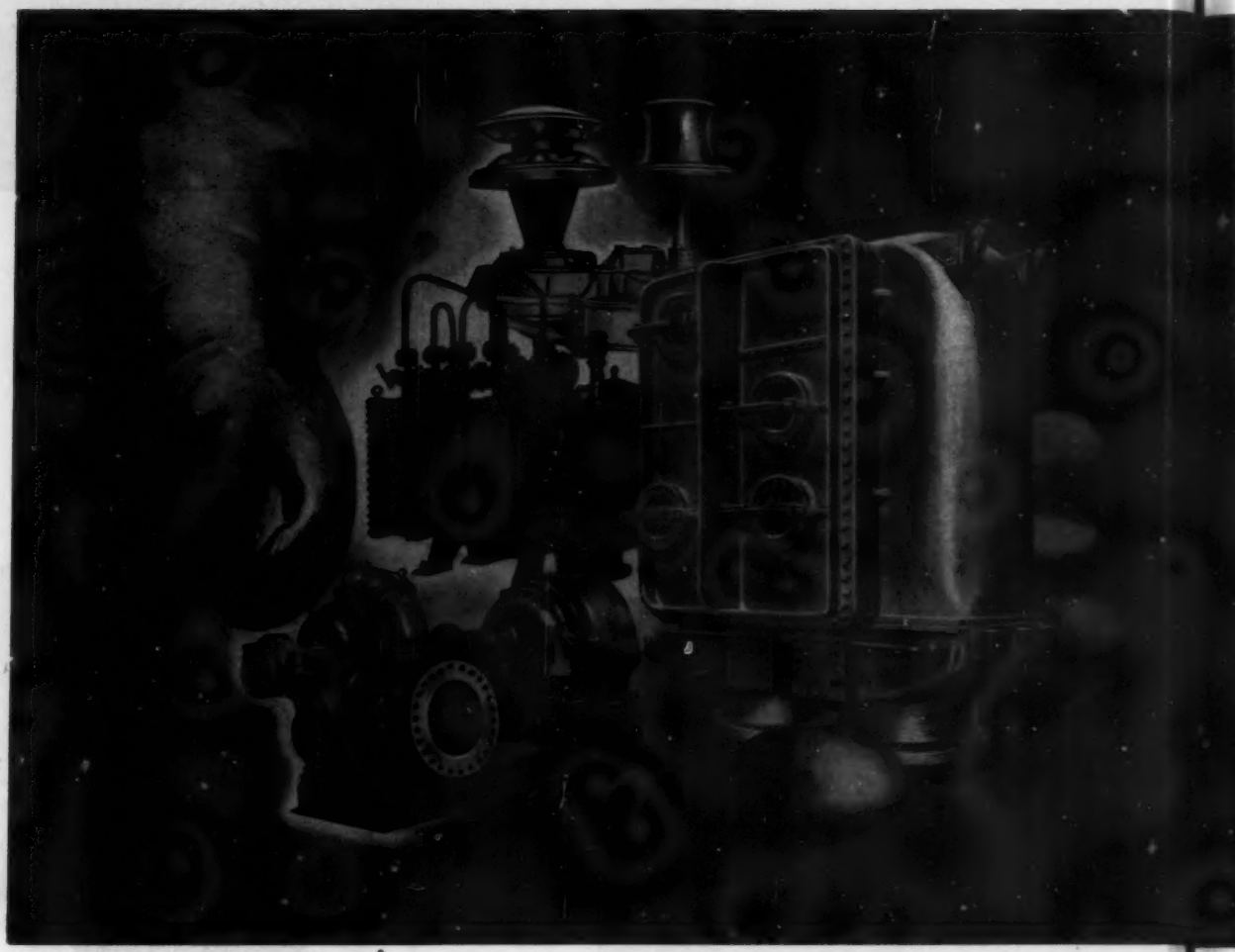

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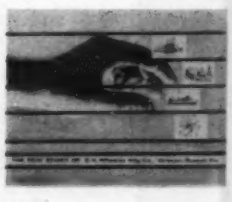

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Books

(Concluded from page 54)

indications of the remarkable feats of hearing possible in the animal kingdom.

The sensitivity and sound engineering design of the ear should come as no surprise, since investigation of other animal senses, particularly sight and smell, has shown that only by pressing physical instrumentation to the limit can scientists do as well (and not always) as these compact biological devices. A sound striking the eardum displaces it an incredibly small amount. For sound pressures of ordinary conversation, say the authors, the displacement is about that of the diameter of the hydrogen molecule, or 10^{-8} cm. One of the roles of the tiny bony chain in the middle ear is that of an impedance matcher, a device familiar to electrical engineers. The three bones of the middle ear, the hammer, anvil, and stirrup, act as a leverage system which reduces the minute motion of the eardrum to a more forceful but still tinier motion of the oval window marking the entrance to the inner ear. Since this oval window is much smaller in area than the eardrum, a further increase in pressure results, so that the pressure in the inner ear can be 30 times or more that on the eardrum, compensating in part for the difference in density between air and the body fluids.

The style of the book is easy and informal. An annotated list of suggested reading and an index are included. Although the authors are three in number, the first person singular is used throughout. The authors allege that this artifice makes for simplicity and unity of thought, which leaves the reader wondering whatever became of the editorial "we."

SCIENTIFIC RUSSIAN WITHOUT TEARS, by J. Whitney Perry, '31; a pamphlet published by *The Chemical Bulletin*, Chicago ($1). ***Reviewed by Secor D. Browne, Assistant Professor of Russian.***

MR. PERRY's very readable short introduction to *Scientific Russian* might be called *Scientific Russian Before Tears* since it provides a concise description of the structure and mechanics of the language prior to the student's settling down to the actual pick-and-shovel work of extracting English meaning from a Russian scientific text.

Scientific Russian Without Tears will be helpful reading for students about to embark on a group or individual course of organized study of scientific Russian. It is not recommended, nor, despite its title, evidently meant as an escape from the necessary, and sometimes near-tearful, realities of memorization, exercises, and tenacious application.

PROJECT SHERWOOD, by Amasa S. Bishop; Doubleday and Co., Inc. ($1.25).

THE AUTHOR was a member of the staff of the Radiation Laboratory at M.I.T. from 1943 to 1946. This is a paperback edition of his much praised account of the U.S. program in controlled fusion, to which a report on progress between June, 1948, and June, 1959, has been added by Arthur E. Ruark, Chief of the Controlled Thermonuclear Branch of the AEC.

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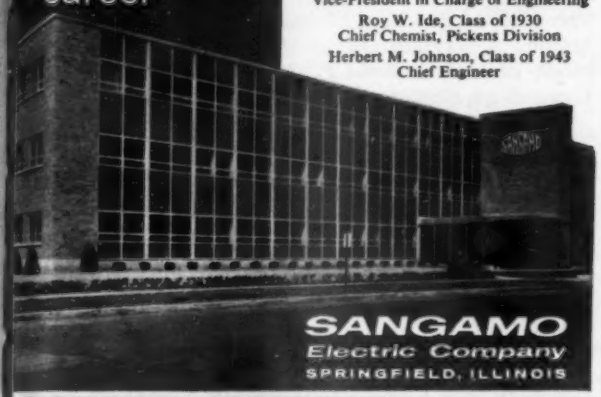

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Institute Yesteryears

25 Years Ago . . .

TRANSMUTATION of atoms of silver into cadmium by means of artificial radioactivity was demonstrated publicly for the first time at a Society of Arts lecture by Professor Robert J. Van de Graaff, of the Department of Physics.

"In his transmutation of elements," said The Review, "the speaker produced artificial radioactivity by radium emanation. Alpha particles from this emanation were made to strike the metallic element, beryllium, causing it to emit neutrons, which, upon striking silver, caused the latter to become artificially radioactive. About 20 seconds after these infinitesimal flying particles had bombarded the silver atoms, some of them spontaneously shot out an electron, thus transmuting themselves into cadmium."

¶ In March, 1935, The Review reported also that direct production of an unsymmetrical molecule had been accomplished by Professor Tenney L. Davis, '13, and Robert Heggie, '33, of the Department of Chemistry. "For ages plants have been producing such molecules in the form of sugar, nicotine, caffeine, camphor, quinine, and a host of other substances that are familiar and important in daily life.

"Davis and Heggie have accomplished what chemists call a total asymmetric synthesis by causing their chemical materials to combine in a beam of circularly polarized light. Such a beam, in simple language, is made up of twisted light. Moonlight is largely polarized light, and diffuse sunlight contains a large proportion. The experiments support the belief that plants accomplish their asymmetric synthesis by reason of the polarized light in which they live."

¶ Congratulations were being received by three newly elected Presidents: *Killey E. Terry, Jr., '06,* of the National Association of Pulp and Paper Mills Superintendents; *José M. Cadenas, '13,* of the University of Havana; and *Donald W. Douglas, '14,* of the Institute of the Aeronautical Sciences . . . and by *Willis R. Whitney, '90,* upon receiving the Edison Medal of the American Institute of Electrical Engineers.

50 Years Ago . . .

"AN IMPORTANT step was taken," in March, 1910, declared The Review's editor, "when a Cosmopolitan Club was formed, with some 60 to 70 members. Although foreign students are not inclined to get together, immediately on the formation of the Club and the occupation of a club room on Boylston Street, directly across from Rogers Building, the foreigners began to fraternize with each other most cordially, and it is believed that this new social link will prove of great value.

"The officers are: President, E. Olaf Christiansen, '10, of Christiania, Norway; First Vice-president, H. T. Shen, '09, of Foochow, China; Second Vice-president, Manuel A Navarro, '10, of Quito, Ecuador; and Secretary-Treasurer, David P. Gaillard, '11, of Culebra, Canal Zone, Panama."

75 Years Ago . . .

"THIS YEAR there will graduate from the Institute the first class that has completed the work in the Course in Electrical Engineering," observed the editor of *The Tech.* "Although other scientific schools have already prepared men for this profession, yet the Institute is a pioneer in this branch of education.

"Already the electrical engineering department is one of the largest in the school, and, in spite of the fact that until a year or two ago no connected work had been done in this branch of instruction, the arrangement of studies has been wonderfully well planned, and does great honor to the Faculty, and especially to the Head of the department.

"We find everywhere young men who, wishing to gain a practical education, think they can find an opening in the field of electrical work. There is something about electricity and its application which is very attractive. The uncertainty as to the true nature of electricity is to many minds a charm."

¶ And, in an adjoining news column, *The Tech* published the following notice: "The Telephone Com-

(Concluded on page 62)

Vannevar Bush Room, M. I. T.
Translucent ceiling conceals wiring, lighting, air-conditioning in this handsome new addition.
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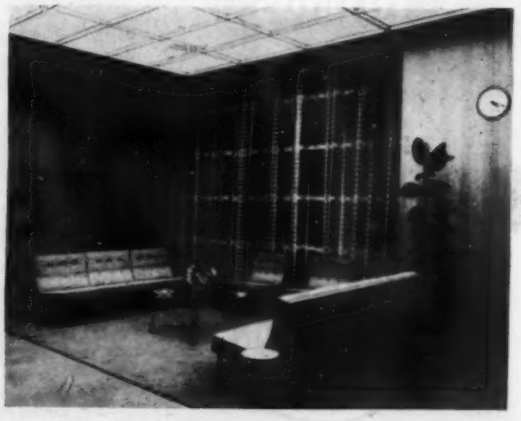

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Patented Construction

A new military approval now allows BIW to offer a high temperature, miniaturized coaxial cable having superior mechanical strength of conductor plus stable, low capacitance not previously available under MIL-C-17B. RG-279/U is known as BIW type COX-3FF-24-MG, Pt. #2059-C-G24. It is particularly applicable as a replacement for RG-179/U.

This cable is designed with the object of providing a coaxial cable expected to encounter flexing and vibration over an extended period of time and to retain relatively stable low capacity characteristics throughout its life. It represents a small diameter cable without requiring the extremely small conductor size of #29 gauge. This cable may be readily wound about a 1" mandrel, and may be expected to withstand twisting and sharp bending without kinking.

This cable fills the need for a small diameter, light weight, dependable coaxial cable of intermediate temperature range for missile applications. It is designed to take the punishment of assembly and harness installations and the brief high temperature life of an expendable weapon.

Test data are tabulated below.

Constructional details in military form follows:

Description	Constructional Details
Inner Conductor	Tinned copper-covered steel wire, nineteen strands. .005 inch diameter. Tensile Strength 55,000 pounds per square inch minimum. O.D. 0.025".
Cable Core	Semi-solid, Type F. Helically wound polytetrafluorethylene filament, covered with polytetrafluorethylene tape or tapes to an overall diameter of .090 inch.
Outer Conductor	Single braid, AWG size #36 silver-covered copper wire. Diameter .110 inch Carriers ..... 16 Ends ..... 5 Picks/inch ..... 15 ± 10%
Moisture Seal	Consisting of one wrap .001 inch polyester film tape, applied with a lap of 60 percent of its width. The moisture seal shall be applied tightly in the best commercial manner.
Jacket	Type V one braid. Color: Tan to Brown. Overall Diameter .125 inch ± .005 inch.

REQUIREMENTS:

Dielectric Strength.....500 volts rms
Capacitance.....20 ± 5 mmf/ft.
Capacitance Stability....± 5 Percent from 200° C to −55° C
Impedance.....65 ± 5 ohms
Temperature Range....−80° C to +150° C

To summarize, RG-279/U is a small diameter, medium-low capacity, flexible, coaxial cable with mechanical strength and stable capacitance over a wide temperature range. We respectfully solicit your inquiries for price, delivery or any other information concerning RG-279/U.

Laboratory Test Report

Cable Type: COX-3FF-24-MG **Subject: Change in Capacity with Mechanical Abuse**

Cap. Before Conditioning 12" Diam. Coil	Cap. when wound around 1" Diam. Mandrel in one direction	% Chg. in Cap.	Cap. when wound around 1" Mandrel in Opposite Direct.	% Chg. in Cap.	Cap. after 4 hrs. in Cold @ −65° F.	% Chg. Cap.	Cap. after 4 hours @ 400° F.	% Chg. in Cap.
172/uuf/8.75' 19.65 uuf/ft. Temp. 74° F.	174 uuf/8.75' 19.88 uuf/ft. Temp. 73° F.	1.01%	174.5 uuf/8.75' 19.95 uuf/ft. Temp. 73° F.	1.016%	176 uuf/8.75' 20.1 uuf/ft. Temp. −70° F.	1.022%	175 uuf 20/uuf/ft. T. 400° F.	1.019%

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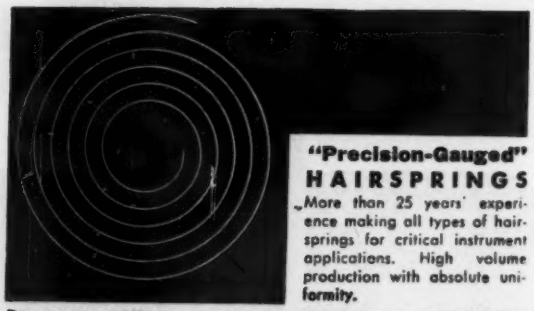

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Institute Yesteryears

(*Concluded from page 60*)

pany threatened to remove the telephone from Rogers Building, if its use by students was not stopped."

85 Years Ago . . .

ON MARCH 17, 1875, in the Institute building at 491 Boylston Street, Boston, there assembled 23 graduates at 7:00 P.M. for the express purpose of perfecting the organization of the Alumni Association of M.I.T. Officers *pro tem* to serve until the first "Annual Meeting" were elected as follows: Robert H. Richards, '68, President; Channing Whitaker, '69, Vice-president; Charles R. Cross, '70, Secretary. At the first "Annual Meeting," which took place on the afternoon of January 27, 1876, the balloting confirmed Richards and Cross for two-year terms as President and Secretary, respectively; and Isaiah S. P. Weeks, '71, was chosen to be Vice-president.*

99 Years Ago . . .

ON MARCH 19, 1861, the Joint Standing Committee on Education of the General Court of the Commonwealth favorably reported a bill for the incorporation of the Massachusetts Institute of Technology. On March 25, the bill was ordered to be engrossed by the House; and on March 29, the same action was taken by the Senate.

---

*Richards, Cross, and Whitaker were, respectively, Heads of the Institute Departments of Mining Engineering, Physics, and Mechanical Engineering.

Richards (1844-1945) retired in 1914 and lived to become, on August 26, 1944, the Institute's first Alumnus centenarian.

Cross (1848-1939), who was a close associate of Alexander Graham Bell, founded at the Institute, in 1882, the first course of electrical engineering leading to a degree in the United States. He became emeritus in 1917.

Whitaker (1843-1913) resigned from the Faculty in 1883 to enter private engineering practice. Prior to registration as a member of the Class of 1869, he was a veteran of the Civil War. Enlisting in the 39th Massachusetts Volunteers, he was wounded and taken prisoner at Spotsylvania, and given up for dead by his family, with the result that he later had the extraordinary experience of reading his own obituary in the Boston *Globe* before he matriculated at M.I.T.!

Weeks (1847-1908) was for 23 years chief engineer of the Burlington Lines west of the Missouri River, during which time 3,000 miles were added to the system under his direction.

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and the prophet replied:
"It is well to give when asked, but it is
*better to give unasked, through understanding."**

Gifts by Will

TO THE

Massachusetts Institute of Technology

The tale is told of Almustafa, the prophet, who, having awaited for many years the ship that would return him to the place from whence he came, was making the final descent to the shore when the folk of Orphalese crowded about him. They besought him before departing to "disclose us to ourselves, and tell us all that has been shown you of that which is between birth and death."

With words of wisdom, an answer appropriate was given to the woman holding a baby, to the ploughman, to the merchant. Begged one, "Speak to us of GIVING," and the prophet replied:

> "It is well to give when asked, but it is better to give unasked, through understanding;
> And to the open-handed the search for one who shall receive is joy greater than giving. All you have shall some day be given;
> Therefore give now, that the season of giving may be yours and not your inheritors'."

Through the years the prophet's words have held true, for even today he who "through understanding" includes the MASSACHUSETTS INSTITUTE OF TECHNOLOGY as a beneficiary in his will can experience thereby a two-fold satisfaction. The successful culmination of his search for a worthy recipient and the anticipated results his generosity will assist in accomplishing. These satisfactions give an added value to the span of man's days and project his usefulness to his fellowmen far into the future.

The Massachusetts Institute of Technology because of the high quality of the education given its students, its effective research work for aiding America in peace as well as in war, and the high character of its governing body and academic staff qualifies as an institution for serving our American ideals for the present and in the years to come.

But the search, the finding, and the anticipated accomplishments are not enough; for without the properly-worded record, man's plans for the future may go awry. Hence the prophet's importuning, "—give now," should be heeded. The giving need not be an immediate physical transaction, for written directions replace the spoken word when the speaker is no longer present, and a donor can frequently make by will a gift which is larger than he can make while living. Truly, *"it is well to give when asked, but it is better to give unasked, through understanding."*

A booklet "Gifts by Will," outlining different forms of bequests to M.I.T., is available to you or to your attorney by writing to:

Director of Development

Massachusetts Institute of Technology

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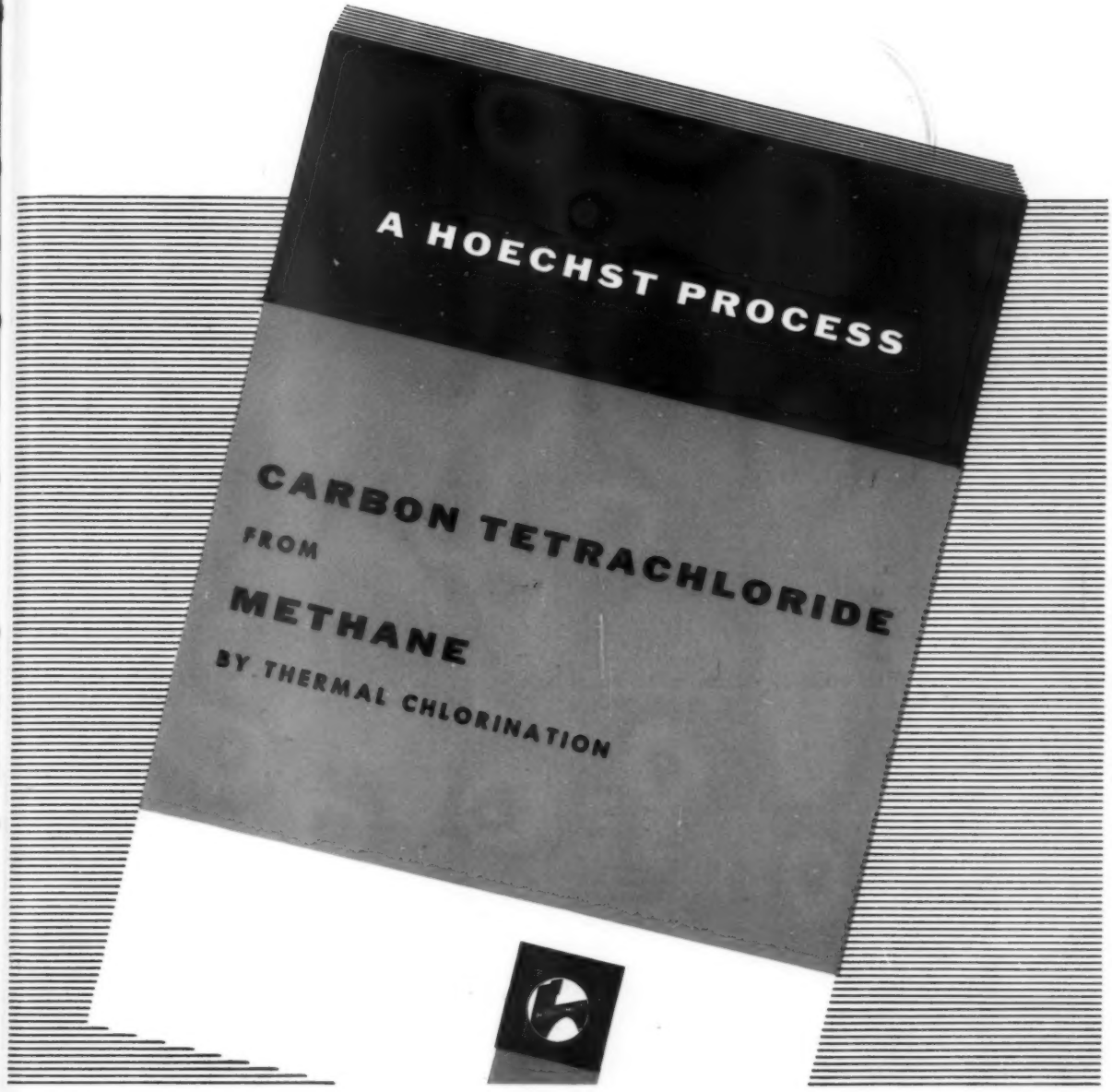
* "The Prophet" by Kahlil Gibran



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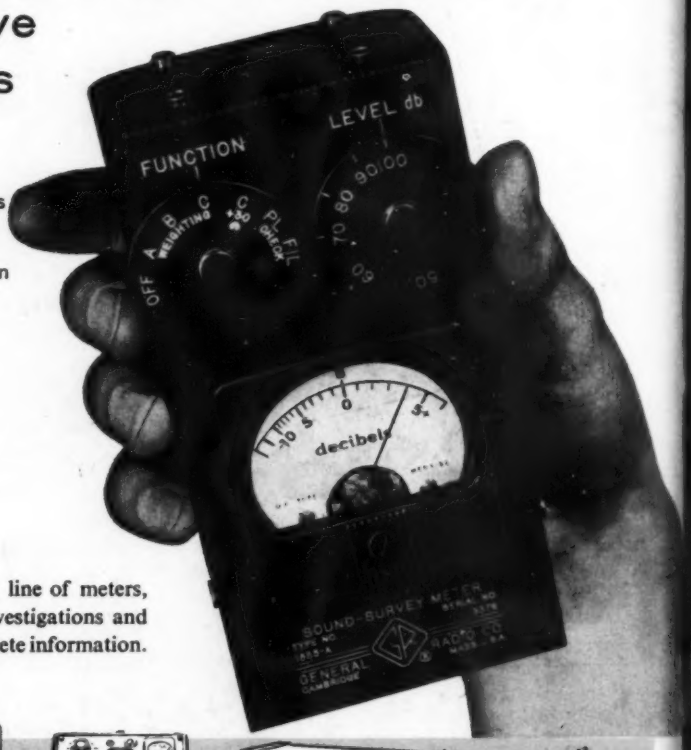

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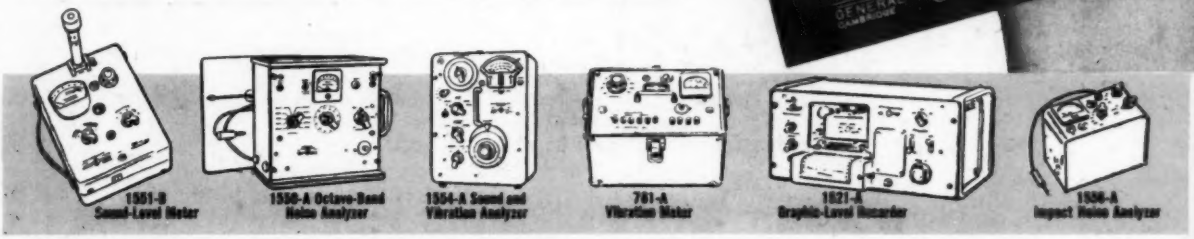

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